Understanding the Impact of COVID-19 on Online Eating Disorder Communities on Reddit

Md Al Amin
Department of Computer Science
North Dakota State University
Fargo, ND, USA
md.al.1@ndsu.edu

Lu Liu
Department of Computer Science
North Dakota State University
Fargo, ND, USA
lu.liu.2@ndsu.edu

ABSTRACT

The social restrictions, disruptions in daily activities, and psychological stressors arising from the COVID-19 pandemic constitute a psychological burden for people worldwide, which can be especially detrimental for individuals with mental disorders like Eating Disorders (ED). In this research, we aim to comprehend how COVID-19 has affected individuals with eating disorders through a comparative analysis of data obtained from online communities. We collected data spanning two years before and after the declaration of the pandemic from the subreddits r/AnorexiaNervosa, r/BingeEatingDisorder, and r/EatingDisorders. The research presents multi-faceted tasks where we analyze the content of each of the subreddits by applying a strategy that combines topic modeling, social network analysis, and time series modeling for a better understanding of these communities on both content and network levels. Through a comparative analysis, we address the discussion topic changes based on users' content and determine how COVID-19 leads to changes in communication patterns within the communities. Finally, we implement time series models like ARIMA, Prophet, LSTM, and Transformer on daily posts and comments count to forecast users' activities within the subreddit and establish a performance comparison of these time series models. The findings indicate that both the content of users' discussions and the level of communication and online support-seeking related to eating disorders on Reddit underwent significant changes during the pandemic. The data of this study is available at this GitHub[1].

CCS CONCEPTS

• **Computing methodologies → Information extraction**; **Artificial intelligence**; **Natural language processing**;

KEYWORDS

Eating Disorder, Topic Modeling, User Interaction, Time Series Intervention Analysis, Reddit

[1]GitHub link for data

1 INTRODUCTION

Eating disorders (EDs) are serious but treatable mental and physical illnesses that can affect people of all genders, ages, races, religions, ethnicities, sexual orientations, body shapes, and weights. According to the National Eating Disorder Association (NEDA)[2]. There are 28.8 million people suffering from clinically significant EDs at some time in their life in the United States only [9].

The COVID-19 pandemic has even worsened ED communities more than their usual activities. The post-pandemic years fundamentally uprooted and transformed the lives of virtually every individual. No longer could people meet or handshake when that meeting or handshake could be a means of death. Uncertainty and fear surrounding the disease, and lack of consistent and reliable information contribute to rising levels of anxiety and stress among people [38], in the United States alone, 37% of individuals exhibit signs of anxiety and depression [16].

Despite the rising mental impact, the increased risks associated with COVID-19 made traditional support avenues, such as group therapies and individual provider visits, difficult or impossible. This has created a complex challenge for individuals with mental health issues. Individuals fighting EDs are among the most impacted by this, as emerging research is beginning to show.

Given the potential for the COVID-19 outbreak to have devastating consequences on human life, it is critical that we work to understand its negative psychological effects. In this work, we use Reddit, a popular social media platform, to study how COVID-19 has impacted the behavior of people posting in ED forums. We focus on three Reddit sub-forums, referred to as subreddits, which are designed to offer peer support for users who are struggling with specific types of ED. We aim to determine whether there are changes related to the pandemic in online ED forums through a comparative study. To measure this, we build topic models to identify the main topics discussed, social network analysis for users' interaction, and time series models to forecast user's activities over posts and comments during the pandemic.

This paper explores the communities of r/EatingDisorders, r/AnorexiaNervosa, and r/BingeEatingDisorder with the aim of addressing the following inquiries:

- How Extensively is the Topic of COVID-19 Addressed within the Selected Subreddits?
- Do Conversational Shifts in Eating Disorder Subreddits Differ Amidst COVID-19?

[2]NEDA

- Do Alternations in Social Interaction Patterns in Eating Disorder Subreddits Differ During COVID-19?
- What methods can be employed to analyze the performance of time series forecasting models on post and comment data?

Our findings include substantially increased rates of posting and commenting in ED subreddits along with strong connectivity between users. A transition of discussion content from usual ED issues to COVID-19-related ED issues. These and other findings provide insights into specific ways in which COVID-19 has not only impacted the behavior of users who discuss ED concerns but also the users who do not have ED problems. To the best of our knowledge, existing research has examined these online support venues and found that during the pandemic years, the specific symptoms of EDs change due to the substantial impacts of the virus on day-to-day life [41]. Some studies only examined the impacts in the first few months of the pandemic which are not sufficient to assess long-term effects [11, 29, 34]. The present study aims to expand the existing analysis by examining data from the first 24 months before and after the declaration of the pandemic, March 2018 - February 2020 and March 2020-February 2022. These date ranges are strategically selected to examine comparative differences between the timelines.

2 RELATED WORK

Eating disorders are severe mental health conditions characterized by unusual eating habits or behaviors related to weight control. Distorted beliefs and attitudes regarding weight, body shape, and eating patterns are central to the development and persistence of these disorders. The nature of these concerns can differ based on gender; in men, for instance, body image issues may revolve around the desire for increased muscularity, while in women, the focus may be more on achieving weight loss[39]. Research has revealed that in 2017, an estimated 16 million individuals globally were affected by anorexia nervosa and bulimia nervosa [23].

There are six main feeding and eating disorders now recognized in diagnostic systems: anorexia nervosa, bulimia nervosa, binge eating disorder, avoidant-restrictive food intake disorder, pica, and rumination disorder. Numerous studies have been done on each type of eating disorder with a variety of ages and sex. To name a few, Jeffrey G *et. al.*[20] address eating disorder among adolescents the Risk for Physical and Mental Disorders During Early Adulthood. Golden *et al*[14] suggest how obesity prevention efforts may lead to the development of an ED in adolescents. Eating disorders and disturbed eating patterns are always associated with mental disorders. Natalie C. *et al*[28] conducted a comprehensive study exploring bidirectional associations between eating disorders and psychiatric disorders.

Social media platforms are rapidly gaining significance as valuable sources of information pertaining to mental health disorders. Reddit serves as an exceptionally well-suited platform for the examination of eating disorders, primarily due to its semi-anonymous nature, which fosters candid user interactions and diminishes inhibitions related to sharing personal experiences [7]. Furthermore, Reddit features subreddits dedicated to serving as forums for eating disorders discussions, such as r/EatingDisorders, r/AnorexiaNervosa, and r/BingeEatingDisorder. These specialized subreddits enable

a more precise analysis of users contending with specific eating disorder conditions.

Several prior studies have concentrated on the characterization of discourse patterns within Reddit communities. Research endeavors have included the analysis of long-term trends in the usage of topics and word choices [6], the exploration of the relationship between user participation styles and their preferences in topics [10], and the examination of discourse patterns specifically related to self-disclosure, the provision of social support, and anonymous posting [7, 31]. Other studies of Reddit eating disorders communities have aimed to quantify and forecast changes in user behavior. Yousrha *et. al.* [12] analyzed the content and the network of the pro-eating disorders (pro-ED) community and the pro-recovery community on Reddit by applying an approach that combines topic modeling, social network analysis, and sentiment analysis. Ashleigh N *et. al.* [35] presented linguistic measures to find dramatic changes in the lives of those with eating disorders (EDs) during the COVID-19 pandemic.

Current research on the confluence of EDs and COVID-19 indicates that the impacts are wide-reaching and felt throughout the world, as one might expect [18, 25, 37]. Two main themes have emerged from the widespread impact: First, people are experiencing various barriers (including social, role, and support), and second, there are unexpected benefits for those battling EDs during the pandemic. The study has indicated that the pandemic has caused wide-ranging social barriers amongst those fighting EDs, including isolation and changes in accountability/responsibility [21], and these social barriers often exacerbate existing negative behaviors. People experiencing stressful life events—such as a death in the family or a pandemic—experience a dramatic increase in harmful coping mechanisms and weight/food control behaviors [24]. As a result, people experiencing EDs have reported an increased usage of harmful coping mechanisms.

Social media analysis has been used to study the impacts of the COVID-19 pandemic and the spread of the virus. Shen *et al.* [33] used Granger causality tests to show that Weibo posts related to COVID-19 symptoms or a diagnosis could be used to predict case counts up to two weeks ahead of time in China. Ordun *et al.* [30] explored topics and network features in COVID-19 tweets. They studied the propagation of information related to the pandemic and showed a relationship between topics and government press briefings. Gencoglu and Gruber [13] created a causal model involving Twitter activity and sentiment, COVID-19 statistics, country demographic statistics, and government interventions. They found that country Twitter usage, new deaths, new infections, and lockdown announcements all impact COVID-19-related Twitter activity.

3 DATA

During this investigation, we utilized the Pushshit API[1] to programmatically extract Reddit posts and comments spanning from March 2018 to February 2022. The declaration of COVID-19 as a global health emergency by the World Health Organization and the United States in March 2020[3] prompted us to categorize our dataset into two segments: the period prior to the pandemic declaration (March 2018 to February 2020), labeled as Pre-Pandemic data, and

---

[3]COVID-19 emergency declaration

Table 1: Pre-Pandemic Subreddit Data

	r/Eating Disorders	r/Anorexia Nervosa	r/BingeEating Disorder	Total
Post	2,345	5,125	11,943	19,413
Comment	11,552	19,620	57,864	89,036

Table 2: Mid-Pandemic Subreddit Data

	r/Eating Disorders	r/Anorexia Nervosa	r/BingeEating Disorder	Total
Post	3,569	16,283	20,093	39,945
Comment	18,804	73,986	91,374	184,164

the period following the declaration (March 2020 to February 2022), referred to as Mid-Pandemic data. Our focus centered on three specific subreddits related to eating disorders: r/EatingDisorders, r/AnorexiaNervosa, and r/BingeEatingDisorder. The selection of these subreddits was underpinned by several considerations. Firstly, we factored in the overall size of the subreddit groups and their active membership. Second, given that these subreddits provide support for various eating disorders, it was plausible to anticipate that their users might have encountered distinct impacts attributable to COVID-19.

Table 1 shows statistics on the number of posts and comments from these three subreddits we chose prior to the epidemic, whereas Table 2 shows data for the middle of the outbreak. It is obvious that from the pre-pandemic to the mid-pandemic era, the numbers of posts and comments on r/EatingDisorders and r/BingeEatingDisorder nearly doubled. The numbers of posts and comments on r/Anorexia-Nervosa increased by more than a factor of two during the middle of the epidemic.

4 METHODOLOGY

In this paper, our objective is to examine the changes in eating disorder activity during the pandemic. Figure 1 illustrates the research framework of our study. We commence by gathering data from our target population, focusing on eating disorders. Subsequently, we conduct data analysis to extract linguistic and network characteristics. Utilizing the analyzed data, we employ LDA topic modeling to identify prominent topics discussed within the dataset. Additionally, we construct a graph network and explore its properties. To further our analysis, we introduce time series intervention analysis. Ultimately, we interpret the findings by visually comparing topics, graph networks, and time series data between the pre-COVID and mid-COVID pandemic periods.

4.1 Data Processing

In this stage, various data processing tasks, including tokenization, cleaning, and normalization, are performed on the Reddit data. All posts and comments undergo tokenization based on whitespace. During normalization, we eliminate inappropriate tokens such as URLs, emojis, images, and non-English words using a comprehensive set of regular expressions[2]. Lemmatization is employed to normalize tokens to their base form, enhancing the representation of text features by consolidating related tokens under

their base forms. Finally, we construct a **term-frequency-inverse-document-frequency (tf-idf)** metric to evaluate the significance of each lemma across the dataset. Less significant lemmas are excluded from the dataset to optimize the performance of topic models.

4.2 Data Analysis

The data analysis in this study unfolds across three distinct phases. The initial phase commences with topic modeling applied to both pre-pandemic and mid-pandemic datasets, facilitating the extraction of valuable insights. Subsequently, we undertake an extensive social network analysis to quantify user activity and interactions within the targeted subreddits. Finally, we employ time series analysis to identify any notable shifts in activity patterns during the pandemic period.

4.2.1 Topic Modeling: To study the changes in discussion content that occurred during the pandemic, we use Latent Dirichlet Allocation (LDA) topic modeling[3]. The reason behind choosing LDA topic modeling is that it is an unsupervised machine learning method and does not require preliminary classification of the documents. LDA has shown great results in online communities relating to mental disorders[2, 5, 27]. To understand the discussion topics that are common within r/EatingDisorders, r/AnorexiaNervosa, and r/BingeEatingDisorder, we train a single topic model on combined posts and comments from these three subreddits. This provides us with a set of topics, where each topic is defined as a distribution over words. We use this trained model to infer topic distributions for each of the subreddits. This helps us analyze changes in the respective subreddits from pre-pandemic to mid-pandemic times. We ensure that discussions from each of the subreddits are equally represented in our dataset over the timeline. We use the implementation of LDA topic modeling provided in the GENSIM Python Library[32] and train models with $k = 5, 10, ..., 50$ topics. We select a single model to use in our analysis by examining their coherence scores, a measure of the semantic similarity of high-probability words within each topic[26]. As coherence tends to increase with increasing k, we select k as the first local maxima of coherence scores for each of the subreddit data pre-pandemic and mid-pandemic.

4.2.2 Social Network Analysis: Social Network Analysis (SNA) is the study of relations between individuals[36]. It is an interdisciplinary descriptive, conceptual, and empirical framework that represents complex systems as networks. The individual who contributes to the group is presented as a node, and the relationship is presented as an edge of the network. Our research focuses on investigating alterations in social interaction patterns within each subreddit. To accomplish this, we establish a set of user interaction metrics, drawing inspiration from previous research in network analysis as applied to social media platforms[36, 43, 44]. In order to carry out our Social Network Analysis (SNA), our initial step involves modeling our community as a social interaction graph denoted as $G = (N, E)$, where N represents the individuals who post and comment within the subreddit, and E constitutes the collection of interactions among them. Here, an interaction is defined as a reply or a comment on a comment within the community. In our study, we use an undirected link and remove self-loops in order to

Figure 1: A general overview of the research architecture of our system
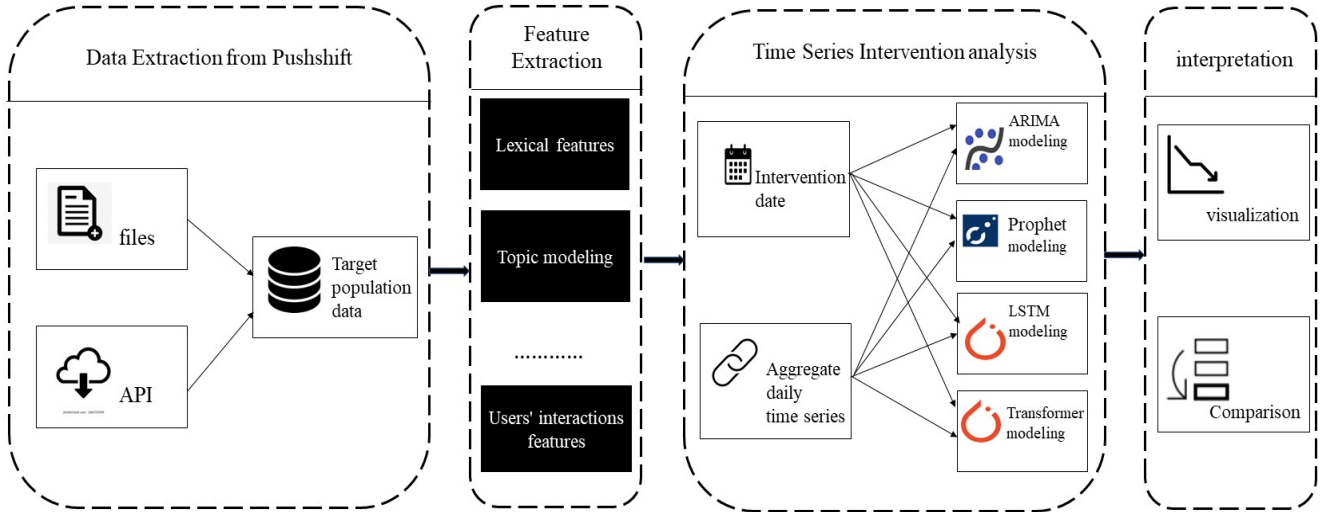
maintain the integrity of our metrics calculations. Social network analysis involves a variety of tasks[36]. We then compute eight metrics commonly used to characterize graphs as our user interaction measures[2], which are described in detail in the Table 3. We use the NetworkX library[15] to assist with graph creation and metric extraction.

4.2.3 Time Series: Time series analysis, a statistical methodology, is focused on examining data points collected, recorded, or evaluated across successive time intervals [45]. In our research inquiry, we employ time series models to forecast user activity by analyzing the daily count of posts and comments. Our approach is influenced by the study of Mrinal Kuram and colleagues [22], where they investigate the impact of an event on user activity within mental health subreddits. Their methodology involves using a t-test to compare observations "before" and "after" a significant event. However, our approach differs in that we consider longer time periods, which allows us to capture seasonal patterns and long-term trends more effectively. We often observe strong trends over time and seasonal fluctuations in our data, rendering direct comparisons of two time periods using a t-test unreliable.

We use **ARIMA**[4], **Prophet**[19], **LSTM**[17], and **Transformer** [40] models to forecast user activities through posts and comments count and compare model performance with respect to **ARIMA** model. To ensure consistency in our analysis, we apply min-max scaling to all the data, a technique that utilizes the minimum and maximum values within the dataset for normalization. Furthermore, we divide the data into training and testing sets, maintaining a uniform 2:1 ratio for all the models. As a pre-processing step, we employ a seven-day rolling mean to smooth the dataset, effectively filtering out short-term fluctuations and outliers. This enables us to better understand the underlying trends and patterns in the data.

5 RESULT AND DISCUSSION

5.1 How Extensively is the Topic of COVID-19 Addressed within the Selected Subreddits?

We utilize the COVID-19 terminology provided in Table 4 to calculate the proportion of posts and comments per month that reference terms associated with COVID-19. Figure 2 illustrates the percentage of posts related to COVID-19, while Figure 3 represents the percentage of comments. We observe that discussions surrounding COVID-19 are prevalent in all three subreddits around the beginning of March 2020. However, r/EatingDisorder subreddit exhibits a higher proportion of COVID-19-related discussions in the posts, whereas r/BingeEatingDisorder features a greater prevalence of such discussions in the comments.

Discussion: When determining the starting point for the COVID-19 period in our research analysis, we selected March 1, 2020, as a meaningful date. On this date, the United States, where a significant portion of Reddit users reside, began to address COVID-19 in a more concerted manner. March 1 closely followed the first reported COVID-19 death in the United States on February 28, and it preceded subsequent developments such as school closures and state lockdowns.

In Figure 2, COVID-19 related discussion reached the first peak in March 2020 and r/EatingDisorder subreddit shows more frequent COVID-19 related posts than other subreddits. This suggests that users in these subreddits are strongly affected by COVID-19. Figure 3 reveals that users commented COVID-19 related discussions more frequent in r/BingeEatingDisorder than other subreddits. This could be the fact that users tried to relate their binge eating disorder related issues to COVID-19 according to their symptoms[42].

Table 3: Names and descriptions of user interaction measures

Metric Name	Description
Node Count $|N|$	Number of unique users who posted or commented
Edge Count $|E|$	Number of unique users who interacted through a reply to a post or comment
Network Density $\frac{2|E|}{|N|(|N|-1)}$	Number of edge in graph over number of possible edges
Connected Component Count	Number of subgraphs in which all pairs of nodes are connected by an edge
Clustering Coefficient	Measure of the degree to which nodes tend to cluster together
Mean Connected Component Size	Mean number of nodes in a connected component
Mean Shortest Path	Mean distance between each pair of vertices that are connected by a path
Network Diameter	Maximum distance between any pair of nodes within a connected component

Table 4: Lexicons of COVID-19 Terms

Original Search Terms			Additional Terms	
2019-ncov	COVID	mers	corona	rona
2019ncov	COVID-19	sars	outbreak	sars-cov-2
coronavirus	COVID19	SARS2	pandemic	virus
SARSCOVID19	wuflu	Wuhan		
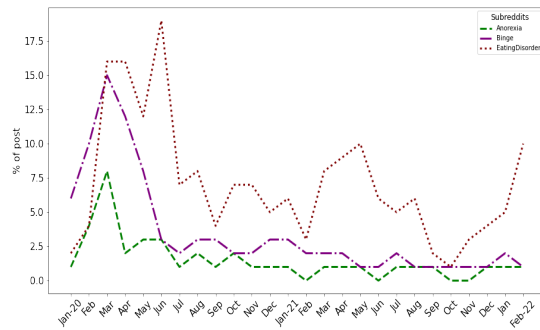
Figure 2: Percentage of posts per month mentioned COVID-19 related words
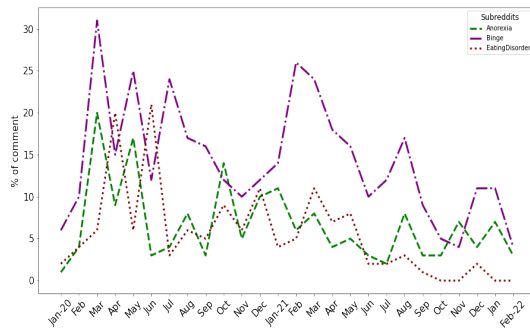
Figure 3: Percentage of comments per month mentioned COVID-19 related words

5.2 Do Conversational Shifts in Eating Disorder Subreddits Differ Amidst COVID-19?

Providing a deeper comprehension of the subjects and debates in these communities, we employ the LDA topic model, utilizing both post and comment data. By comparing the results of topic modeling before and during the pandemic, we enhance our understanding of the communities. Tables 7 to 12 present the outcomes of our LDA topic model. This model was developed using the pre-processed data from both pre-pandemic and mid-pandemic periods for each subreddit. Detailed information on our approach to constructing this model can be found in subsection 4.2.1. To enhance our understanding of the discussion evolution from the pre-pandemic to mid-pandemic data, we manually assigned topic labels to each of these topics. These labels were based on our observations of the high-probability words provided by the model.

Discussion: Table 7 displays the topics that were discussed in the pre-pandemic data of the r/EatingDisorder subreddit. In contrast, Table 8 illustrates the topics from the mid-pandemic data. Most of the topics in Table 7 are related to eating disorder issues like "BODY IMAGE AND CONTROL STRUGGLES", "EATING HABITS AND MEDICATION", "BULIMIA RECOVERY". Where as during the mid-pandemic, we noticed a significant increase in discussions related to COVID-19. The "EATING HABIT IN COVID" topic revolved around meal planning, dietary choices, calorie intake, and healthy eating during the pandemic. The "SEEKING SUPPORT COVID" topic centered on seeking help, advice, treatment, support, and recovery strategies from the community during the pandemic. The "POST-COVID EXPERIENCE" topic shared information about individuals' experiences after being infected by COVID-19, including details about taste, weakness, recovery advice, and more.

Similarly, we notice a variety of topics discussed related to anorexia nervosa in Table 9. However, there are notable shifts in the topics discussed after the onset of the pandemic in Table 10. One dominant topic revolves around the rules and regulations of the r/Anorexia-Nervosa subreddit, encompassing discussions about subreddit rules, posts, comments, and the actions (such as immediate reporting) taken for violations of community regulations. Another prominent topic centers on "POST-COVID EXPERIENCE," addressing aspects like COVID-19, medications, side effects, pain, and stomach issues. Additionally, there's a focus on "LOCK DOWN AND FAMILY," reflecting discussions related to lockdown measures, family dynamics, and the impact of the pandemic on various aspects

of life. These shifts indicate that the community was significantly influenced by the COVID-19 pandemic, with members seeking advice and information about maintaining a "POST-COVID EXPERIENCE" during these challenging times.

By comparing topics in Table 11 and Table 12, it can easily be demonstrated that r/BingeEatingDisorder community was indeed affected by COVID-19 restrictions. The "COVID RESTRICTION" topic refers to lockdown restrictions that individuals experienced during the pandemic. The "DAILY ROUTINE" topic reflects changes in people's daily activities and mobility due to pandemic-related lockdowns. Furthermore, the "FAMILY CONCERNS" topic underscores people's worries about their family members and their eating habits during the pandemic. These findings highlight the pandemic's influence on the community's discussions and concerns.

5.3 Do Alternations in Social Interaction Patterns in Eating Disorder Subreddits Differ During COVID-19?

Our research aims to examine the shifts in social interaction dynamics within three chosen eating disorder subreddits, comparing the pre-pandemic period to the mid-pandemic period. To achieve this, we constructed separate social networks for each subreddit during both time periods. These networks help us measure social interaction, as detailed in Table 3, and we further analyze the alterations in network structure by calculating various centrality metrics. Table 6 presents the social interaction metrics for the r/EatingDisorder, r/AnorexiaNervosa, and r/BingeEatingDisorder subreddits, respectively. We observe significant shifts in these metrics across all three subreddits.

Discussion: Each community within subreddits exhibits characteristics of sparse networks, characterized by their low density and the presence of a significant connected subgraph alongside a minimal number of two-node connected components[8]. The increasing number of node and edge count signify user's engagement has increased within the subreddit, such as seeking help, commenting on others' posts for guidance, sharing experiences, and expressing their feelings. The increase in connected components, mean connected component and mean shortest path suggest that a broader range of topics are being discussed in these subreddits. This observation is consistent with our findings from topic modeling (as discussed in subsection 5.2), where we identified a wide array of prominent topics being discussed during both time periods.

5.4 What methods can be employed to analyze the performance of time series forecasting models on post and comment data?

In this study, our objective is to assess the effectiveness of a time series model based on Transformers using data related to post and comment counts. We conduct a comparative analysis of the Transformer-based model with ARIMA, Prophet, and LSTM models. The Root Mean Square Error (RMSE) values and their relative comparisons are presented in Table 5. The LSTM model demonstrates a relative improvement of 50.98% for posts, 52.88% for comments, and 50.47% for the combined count of posts and comments when compared to the Prophet model. It's worth noting that we initially

Table 5: Summary of Time Series Models on Posts and Comments Count

Time Series Model	Posts	Comments	Total Posts and Comments
ARIMA	0.685 (0%)	0.758 (0%)	0.754 (0%)
Prophet	0.102 (-85.10%)	0.104 (-86.28%)	0.105 (-86.07%)
LSTM	0.050 (-92.70%)	0.049 (-93.54%)	0.052 (-93.10%)
Transformer	0.0715 (-89.56%)	0.0959 (-87.35%)	0.0917 (-87.83%)

expected the Transformer model to deliver superior performance compared to the LSTM model. However, we observe that the Transformer model's performance is slightly lower than LSTM.

Our results indicate that LSTM demonstrates exceptional performance compared to other models. Deep learning models, such as LSTM, possess the capacity to effectively capture intricate patterns, retain them in memory, and discern dependencies within the data, surpassing the capabilities of linear models like ARIMA and Prophet.

6 CONCLUSION

In our research study, we carried out a comparative analysis using Latent Dirichlet Allocation (LDA) topic modeling to assess how COVID-19 has influenced the online behavior of individuals who discuss eating disorder concerns by analyzing activities within r/EatingDisorder, r/AnorexiaNervosa, and r/BingeEatingDisorder communities on Reddit. Primarily, we observed a significant surge in the number of users across all the subreddits following the declaration of COVID-19 as a pandemic. These subreddits transformed into hubs for sharing information related to the COVID-19 pandemic, new guidelines, and seeking assistance and support. Concerned users increased their participation in these forums by sharing valuable insights and guidance. However, we made the assumption that most Reddit users are based in the USA, as demographic data was unavailable. The impact of COVID-19 on eating disorders can differ significantly by region, so generalizing our findings may not be appropriate without taking regional disparities into account. Additionally, while Latent Dirichlet Allocation (LDA) is adept at identifying topics within a corpus, interpreting and assigning meaningful labels to these topics can be challenging. LDA-generated topics often tend to be abstract and require human judgment for accurate interpretation.

We noticed noteworthy changes in the discussion content within the various subreddits. In r/EatingDisorders, there was a predominant focus on topics such as social support, coping with eating habits during the COVID-19 pandemic, post-COVID experiences, and resources like telemedicine during the lockdown. The r/AnorexiaNervosa subreddit witnessed considerable discussions on changes in subreddit guidelines, seeking support for recovery, post-COVID experiences, lockdown-related issues, food, and family matters. In the r/BingeEatingDisorder subreddit, there was a notable shift in

Table 6: User Interaction Metrics for r/EatingDisorder,r/AnorexiaNervosa, and r/BingeEatingDisorder Social Network

Metric Name	r/EatingDisorder		r/AnorexiaNervosa		r/BingeEatingDisorder	
	Pre-Pandemic	Mid-Pandemic	Pre-Pandemic	Mid-Pandemic	Pre-Pandemic	Mid-Pandemic
Node Count	3,164	4,839	4,079	10,936	9,733	15,953
Edge Count	4,336	6,396	9,260	34,266	28,875	46,050
Network Density	0.0009	0.0005	0.0011	0.00057	0.00060	0.00036
Connected Components Count	2	1	360	710	611	1183
Clustering Coefficient	0.1783	0.1597	0.1365	0.1783	0.1604	0.1619
Mean Connected Component	1,582	4,839	11.3305	15.4028	15.929	13.4852
Mean Shortest Path	2.2499	2.2191	3.2629	3.0899	3.1525	3.13307
Network Diameter	6	6	8	8	8	9

discussions toward disruptions in daily routines, changes in eating habits, issues like insomnia, seeking community assistance and support, and discussions related to mental health disorders. These discussion topics vividly underscore the intensified impact of COVID-19 on individuals dealing with eating disorders.

ACKNOWLEDGMENTS

REFERENCES

[1] Jason Baumgartner, Savvas Zannettou, Brian Keegan, Megan Squire, and Jeremy Blackburn. 2020. The Pushshift Reddit Dataset. *Proceedings of the International AAAI Conference on Web and Social Media* 14 (May 2020), 830–839. https://doi.org/10.1609/icwsm.v14i1.7347

[2] Laura Biester, Katie Matton, Janarthanan Rajendran, Emily Mower Provost, and Rada Mihalcea. 2021. Understanding the Impact of COVID-19 on Online Mental Health Forums. *ACM Transactions on Management Information Systems* 12, 4 (Sept. 2021), 1–28. https://doi.org/10.1145/3458770

[3] Andrew Y. Blei, David M. Ng and Michael I. Jordan. 2003. Latent Dirichlet Allocation. *J. Mach. Learn. Res.* 3, null (mar 2003), 993–1022. https://doi.org/10.5555/944919.944937

[4] George EP Box and David A Pierce. 1970. Distribution of residual autocorrelations in autoregressive-integrated moving average time series models. *Journal of the American statistical Association* 65, 332 (1970), 1509–1526.

[5] Bradley Carron-Arthur, Julia Reynolds, Kylie Bennett, Anthony Bennett, and Kathleen M. Griffiths. 2016. What's all the talk about? Topic modelling in a mental health Internet support group. *BMC Psychiatry* 16, 1 (Oct. 2016). https://doi.org/10.1186/s12888-016-1073-5

[6] Dante Chakravorti, Kathleen Law, Jonathan Gemmell, and Daniela Raicu. 2018. Detecting and Characterizing Trends in Online Mental Health Discussions. In *2018 IEEE International Conference on Data Mining Workshops (ICDMW)*. IEEE. https://doi.org/10.1109/icdmw.2018.00107

[7] Munmun De Choudhury and Sushovan De. 2014. Mental Health Discourse on reddit: Self-Disclosure, Social Support, and Anonymity. *Proceedings of the International AAAI Conference on Web and Social Media* 8, 1 (May 2014), 71–80. https://doi.org/10.1609/icwsm.v8i1.14526

[8] Nadezhda T Doncheva, Yassen Assenov, Francisco S Domingues, and Mario Albrecht. 2012. Topological analysis and interactive visualization of biological networks and protein structures. *Nature Protocols* 7, 4 (March 2012), 670–685. https://doi.org/10.1038/nprot.2012.004

[9] Deloitte Access Economics. June 2020. The Social and Economic Cost of Eating Disorders in the United States of America: A Report for the Strategic Training Initiative for the Prevention of Eating Disorders and the Academy for Eating Disorders. https://www.nationaleatingdisorders.org/statistics/ Accessed on March 12, 2024.

[10] Johannes Feldhege, Markus Moessner, and Stephanie Bauer. 2020. Who says what? Content and participation characteristics in an online depression community. *Journal of Affective Disorders* 263 (Feb. 2020), 521–527. https://doi.org/10.1016/j.jad.2019.11.007

[11] Johannes Feldhege, Markus Moessner, Markus Wolf, Stephanie Bauer, et al. 2021. Changes in language style and topics in an online eating disorder community

[12] Yousra Fettach and Lamia Benhiba. 2019. Pro-Eating Disorders and Pro-Recovery Communities on Reddit. In *Proceedings of the 21st International Conference on Information Integration and Web-based Applications &amp Services*. ACM. https://doi.org/10.1145/3366030.3366058

[13] Oguzhan Gencoglu and Mathias Gruber. 2020. Causal Modeling of Twitter Activity during COVID-19. *Computation* 8, 4 (Sept. 2020), 85. https://doi.org/10.3390/computation8040085

[14] Neville H. Golden, Marcie Schneider, Christine Wood, Stephen Daniels, Steven Abrams, Mark Corkins, Sarah de Ferranti, Sheela N. Magge, Sarah Schwarzenberg, Paula K. Braverman, William Adelman, Elizabeth M. Alderman, Cora C. Breuner, David A. Levine, Arik V. Marcell, Rebecca O'Brien, Stephen Pont, Christopher Bolling, Stephen Cook, Lenna Liu, Robert Schwartz, Wendelin Slusser, , and and. 2016. Preventing Obesity and Eating Disorders in Adolescents. *Pediatrics* 138, 3 (Sept. 2016). https://doi.org/10.1542/peds.2016-1649

[15] Aric Hagberg, Pieter J. Swart, and Daniel A. Schult. [n. d.]. Exploring network structure, dynamics, and function using NetworkX. ([n. d.]). https://www.osti.gov/biblio/960616

[16] Fengyi Hao, Wanqiu Tan, Li Jiang, Ling Zhang, Xinling Zhao, Yiran Zou, Yirong Hu, Xi Luo, Xiaojiang Jiang, Roger S. McIntyre, Bach Tran, Jiaqian Sun, Zhisong Zhang, Roger Ho, Cyrus Ho, and Wilson Tam. 2020. Do psychiatric patients experience more psychiatric symptoms during COVID-19 pandemic and lockdown? A case-control study with service and research implications for immunopsychiatry. *Brain, Behavior, and Immunity* 87 (July 2020), 100–106. https://doi.org/10.1016/j.bbi.2020.04.069

[17] Sepp Hochreiter and Jürgen Schmidhuber. 1997. Long Short-Term Memory. *Neural Computation* 9, 8 (Nov. 1997), 1735–1780. https://doi.org/10.1162/neco.1997.9.8.1735

[18] Emily A Holmes, Rory C O'Connor, V Hugh Perry, Irene Tracey, Simon Wessely, Louise Arseneault, Clive Ballard, Helen Christensen, Roxane Cohen Silver, Ian Everall, Tamsin Ford, Ann John, Thomas Kabir, Kate King, Ira Madan, Susan Michie, Andrew K Przybylski, Roz Shafran, Angela Sweeney, Carol M Worthman, Lucy Yardley, Katherine Cowan, Claire Cope, Matthew Hotopf, and Ed Bullmore. 2020. Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *The Lancet Psychiatry* 7, 6 (June 2020), 547–560. https://doi.org/10.1016/s2215-0366(20)30168-1

[19] Bineet Kumar Jha and Shilpa Pande. 2021. Time Series Forecasting Model for Supermarket Sales using FB-Prophet. In *2021 5th International Conference on Computing Methodologies and Communication (ICCMC)*. IEEE. https://doi.org/10.1109/iccmc51019.2021.9418033

[20] Jeffrey G. Johnson, Patricia Cohen, Stephanie Kasen, and Judith S. Brook. 2002. Eating Disorders During Adolescence and the Risk for Physical and Mental Disorders During Early Adulthood. *Archives of General Psychiatry* 59, 6 (June 2002), 545. https://doi.org/10.1001/archpsyc.59.6.545

[21] Mohsen Khosravi. 2020. The challenges ahead for patients with feeding and eating disorders during the COVID-19 pandemic. *Journal of Eating Disorders* 8, 1 (Sept. 2020). https://doi.org/10.1186/s40337-020-00322-3

[22] Mrinal Kumar, Mark Dredze, Glen Coppersmith, and Munmun De Choudhury. 2015. Detecting Changes in Suicide Content Manifested in Social Media Following Celebrity Suicides. In *Proceedings of the 26th ACM Conference on Hypertext &amp Social Media - HT '15*. ACM Press. https://doi.org/10.1145/2700171.2791026

[23] The Lancet. 2020. Eating disorders: innovation and progress urgently needed. , 840 pages.

[24] Katie Loth, Patricia van den Berg, Marla E. Eisenberg, and Dianne Neumark-Sztainer. 2008. Stressful Life Events and Disordered Eating Behaviors: Findings from Project EAT. *Journal of Adolescent Health* 43, 5 (Nov. 2008), 514–516. https://doi.org/10.1016/j.jadohealth.2008.03.007

[25] Paulo P. P. Machado, Ana Pinto-Bastos, Rita Ramos, Tânia F. Rodrigues, Elsa Louro, Sónia Gonçalves, Isabel Brandão, and Ana Vaz. 2020. Impact of COVID-19 lockdown measures on a cohort of eating disorders patients. *Journal of Eating Disorders* 8, 1 (Nov. 2020). https://doi.org/10.1186/s40337-020-00340-1

[26] David Mimno, Hanna Wallach, Edmund Talley, Miriam Leenders, and Andrew McCallum. 2011. Optimizing Semantic Coherence in Topic Models. In *Proceedings of the 2011 Conference on Empirical Methods in Natural Language Processing.* Association for Computational Linguistics, Edinburgh, Scotland, UK., 262–272. https://aclanthology.org/D11-1024

[27] Markus Moessner, Johannes Feldhege, Markus Wolf, and Stephanie Bauer. 2018. Analyzing big data in social media: Text and network analyses of an eating disorder forum. *International Journal of Eating Disorders* 51, 7 (May 2018), 656–667. https://doi.org/10.1002/eat.22878

[28] Natalie C. Momen, Oleguer Plana-Ripoll, Zeynep Yilmaz, Laura M. Thornton, John J. McGrath, Cynthia M. Bulik, and Liselotte Vogdrup Petersen. 2022. Comorbidity between eating disorders and psychiatric disorders. *International Journal of Eating Disorders* 55, 4 (Jan. 2022), 505–517. https://doi.org/10.1002/eat.23687

[29] Sara K Nutley, Alyssa M Falise, Rebecca Henderson, Vasiliki Apostolou, Carol A Mathews, and Catherine W Striley. 2021. Impact of the COVID-19 pandemic on disordered eating behavior: Qualitative analysis of social media posts. *JMIR mental health* 8, 1 (2021), e26011.

[30] Catherine Ordun, Sanjay Purushotham, and Edward Raff. 2020. Exploratory Analysis of Covid-19 Tweets using Topic Modeling, UMAP, and DiGraphs. (2020). https://doi.org/10.48550/ARXIV.2005.03082

[31] Umashanthi Pavalanathan and Munmun De Choudhury. 2015. Identity Management and Mental Health Discourse in Social Media. In *Proceedings of the 24th International Conference on World Wide Web.* ACM. https://doi.org/10.1145/2740908.2743049

[32] Radim Řehůřek and Petr Sojka. 2010. Software Framework for Topic Modelling with Large Corpora. In *Proceedings of the LREC 2010 Workshop on New Challenges for NLP Frameworks.* ELRA, Valletta, Malta, 45–50. http://is.muni.cz/publication/884893/en.

[33] Cuihua Shen, Anfan Chen, Chen Luo, Jingwen Zhang, Bo Feng, and Wang Liao. 2020. Using Reports of Symptoms and Diagnoses on Social Media to Predict COVID-19 Case Counts in Mainland China: Observational Infoveillance Study. *Journal of Medical Internet Research* 22, 5 (May 2020), e19421. https://doi.org/10.2196/19421

[34] Ashleigh N Shields, Elise Taylor, and Jessica R Welch. 2022. Understanding the conversation around COVID-19 and eating disorders: A thematic analysis of Reddit. *Journal of eating disorders* 10, 1 (2022), 8.

[35] Ashleigh N. Shields, Elise Taylor, and Jessica R. Welch. 2022. Understanding the conversation around COVID-19 and eating disorders: A thematic analysis of Reddit. *Journal of Eating Disorders* 10, 1 (Jan. 2022). https://doi.org/10.1186/s40337-022-00530-z

[36] Lei Tang and Huan Liu. 2010. Graph Mining Applications to Social Network Analysis. In *Managing and Mining Graph Data.* Springer US, 487–513. https://doi.org/10.1007/978-1-4419-6045-0_16

[37] Jet D. Termorshuizen, Hunna J. Watson, Laura M. Thornton, Stina Borg, Rachael E. Flatt, Casey M. MacDermod, Lauren E. Harper, Eric F. van Furth, Christine M. Peat, and Cynthia M. Bulik. 2020. Early impact of scpCOVID/scp-19 on individuals with scpself-reported/scp eating disorders: A survey of ~1, 000 individuals in the United States and the Netherlands. *International Journal of Eating Disorders* 53, 11 (July 2020), 1780–1790. https://doi.org/10.1002/eat.23353

[38] Julio Torales, Marcelo O'Higgins, João Mauricio Castaldelli-Maia, and Antonio Ventriglio. 2020. The outbreak of COVID-19 coronavirus and its impact on global mental health. *International Journal of Social Psychiatry* 66, 4 (March 2020), 317–320. https://doi.org/10.1177/0020764020915212

[39] Janet Treasure, Tiago Antunes Duarte, and Ulrike Schmidt. 2020. Eating disorders. *The Lancet* 395, 10227 (March 2020), 899–911. https://doi.org/10.1016/s0140-6736(20)30059-3

[40] Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Lukasz Kaiser, and Illia Polosukhin. 2017. Attention Is All You Need. https://doi.org/10.48550/ARXIV.1706.03762

[41] L. Vuillier, L. May, M. Greville-Harris, R. Surman, and R. L. Moseley. 2021. The impact of the COVID-19 pandemic on individuals with eating disorders: the role of emotion regulation and exploration of online treatment experiences. *Journal of Eating Disorders* 9, 1 (Jan. 2021). https://doi.org/10.1186/s40337-020-00362-9

[42] Tao Wang, Markus Brede, Antonella Ianni, and Emmanouil Mentzakis. 2017. Detecting and Characterizing Eating-Disorder Communities on Social Media. In *Proceedings of the Tenth ACM International Conference on Web Search and Data Mining.* ACM. https://doi.org/10.1145/3018661.3018706

[43] Hywel T.P. Williams, James R. McMurray, Tim Kurz, and F. Hugo Lambert. 2015. Network analysis reveals open forums and echo chambers in social media discussions of climate change. *Global Environmental Change* 32 (May 2015), 126–138. https://doi.org/10.1016/j.gloenvcha.2015.03.006

[44] Christo Wilson, Bryce Boe, Alessandra Sala, Krishna P.N. Puttaswamy, and Ben Y. Zhao. 2009. User interactions in social networks and their implications. In *Proceedings of the 4th ACM European conference on Computer systems.* ACM. https://doi.org/10.1145/1519065.1519089

[45] Neo Wu, Bradley Green, Xue Ben, and Shawn O'Banion. 2020. Deep Transformer Models for Time Series Forecasting: The Influenza Prevalence Case. https://doi.org/10.48550/ARXIV.2001.08317

Table 7: Main result of topic modeling for the pre-pandemic r/EatingDisorder subreddit

Annotated Labels	High Probability Words
Recovery and Resilience	recovery recover thought life period relapse healthy thank month gain experience
Body Image and Control Struggles	gain thought fat change back lose control never come keep feeling give
Family and Therapeutic Support	therapy parent therapist thought talk love mother control issue always support
Supportive/Trigger Relationships	friend support trigger love understand relationship care situation partner struggle
Eating Habits and Medication	meal hungry stomach calorie doctor appetite drink gain water problem advice
Bulimia Recovery	binge-purge stop restrict bulimia cycle control advice gain eating calorie struggle
Vegan Diet and Challenges	vegan diet healthy problem hard recover trigger control health big struggle
Exercises	exercise gym gain lose healthy calorie fat loss underweight goal health hard normal
Mental Health in University Life	university mental health happy recover professional right back worry fight life
Depression and Anxiety	depression anxiety develop never hard life stop post serious purge sign disordered
Physical and Behavioral Challenges	pain sleep throw binge exercise starve lose calorie issue bulimia smile concerned

Table 8: Main result of topic modeling for the mid-pandemic r/EatingDisorder subreddit

Annotated Labels	High Probability Words
Eating Habits in COVID	meal binge work snack healthy covid restrict diet plan calorie hungry stop keep use full
Supportive Relationship	friend talk sister ask family trigger recovery understand post comment mom deal person
Seeking Support COVID	recovery treatment support recover covid thank struggle hard therapy advice ask understand
Appetite Challenges	hungry stomach hunger appetite meal drink normal doctor recovery struggle put sick
Exercises	exercise work workout gym healthy walk goal hard enjoy focus recovery struggle always use
Balanced/Healthy Diet	healthy health diet vegan scale weigh lose restriction change work behavior stop life loss
Emotional Struggles	life believe never fault struggle right voice self love blame matter attention thought find
Post-COVID Experience	covid clothe wear buy like new cook taste thank meat size recovery advice never weak find put
Symptoms	symptom pain stomach issue doctor bulimia problem diagnose sleep experience cause damage
Medication	medication medical nauseous nausea doctor anxiety appetite issue experience month cause

Table 9: Main result of topic modeling for the pre-pandemic r/AnorexiaNervosa subreddit

Annotated Labels	High Probability Words
Body Image & Societal Perceptions	people skinny body think look say thin weight fat always want way hate thing
Support and Communication	help tell say friend talk want ask people make thing need good understand go care
Recovery Challenges	binge time food body need really hard keep stop want try week well scared bad go
Diagnosing Anorexia Nervosa	anorexia disorder anorexic weight diagnose doctor people underweight food restrict
Meal Plan/Caloric Intake	food day calorie meal make go dinner good time want snack lunch cook think know
Perseverance and Recovery	start body time go recovery long first happen take year slow think recover restrict
Treatment and Support	treatment go help disorder ed therapist need hospital doctor inpatient post place
Positivity and Hopefulness	thank recovery good hope post love well happy relapse much recover proud make
Self-control and Hunger	self control brain hungry hunger starve feeling think thought sleep bed help tip work
Weight Tracking	weight gain lose time weigh go pound healthy scale day start calorie month loss lb
Physical Symptoms	stomach pain hair loss body cold water drink take lot vitamin help sure thing
Negative Perception	hate disgusting look go time fat make know wear clothe fit size see mirror want cry
Mental Health Effects	low dream faint anxiety smoke self-harm heart drug doctor anorexia cause problem

Table 10: Main result of topic modeling for the mid-pandemic r/AnorexiaNervosa subreddit

Annotated Labels	High Probability Words
Subreddit Rules and Guidelines	subreddit rule harmful post comment op report immediately advice read user moderator
Positivity	recovery recover thank proud deserve well much hope happy love hard body life today
Treatment and Support	doctor help need go therapist know tell disorder talk take support therapy struggle
Perseverance and Recovery	back year start recover go recovery relapse month still ed restrict think long bad period
Relationship and Communication	relationship talk tell find control love think understand need help issue situation sound
Stigma and Community Support	anorexia, disorder ed people person trigger post comment think see sub talk call means
Experiencing Anorexia	anorexic anorexia disorder underweight overweight control body diagnose healthy valid
Physical Health and Symptoms	symptom doctor drink low body take water cause energy heart work help vitamin blood
Post-COVID Experience	covid medication anxiety depression pain bad side effect pain stomach wake night sleep
Lockdown and Family	mom parent dad sister mother mum family lockdown home work school start year food
Seeking Advice on Dietary	ask question answer information doctor allow advice vegetarian seem medical subreddit
Anorexia Side Effect	hair loss fall skin dry grow tooth face thin sink take mouth shower look wound

Table 11: Main result of topic modeling for the pre-pandemic r/BingeEatingDisorder subreddit

Annotated Labels	High Probability Words
Seeking Help	people say tell talk ask issue problem think understand disorder help see bed thing try problem
Dietary Restriction	meal snack restriction restrict calorie normal hungry hunger body hunger try healthy food much
Mental Health	brain urge thought think mind control give try read thing habit way stop want plan never book
Insomnia	night sleep wake bed episode happen urge pm hour morning try work really well think happen
Physical Stress	stomach pain ache bad sick stop think well year purge really much still start happen anymore sorry
Emotion	emotion emotional comfort feeling work find hard stress trigger think watch also eating problem
Negative Perception	fuck fucking shit hate think night much cry night look fat love body man want see thing
Treatment	doctor vyvanse medication psychiatrist adhd prescribe work med start month side effect experience
Expenditure	money dollar buy order spend shop store home place food car work store alone drive take live
Family and Friends	family home house friend week holiday come start leave dinner buy junk candy chocolate cookie
Addiction	addicted addiction addict drug alcoholic drink sugar carb keto diet craving work protein fat
Life Style Changes	quit smoking smoke weed challenge change meme behavior munchie work job travel week month

Table 12: Main result of topic modeling for the mid-pandemic r/BingeEatingDisorder subreddit

Annotated Labels	High Probability Words
Struggle and Hope	struggle hard hate bad wish hope want think sorry time try much well stop thing right time
Community Help	post comment people struggle support talk link share help thank love find need look good helpful
Positivity	good great happy proud amazing well think thank time day today week month keep progress
Diet and Nutrition	diet calorie protein carb high sugar keto carb fat day stomach make amount hungry count think
Body and Eating Habits	body physical physically point hunger starve overeat fuel look notice point mental period time
COVID Restriction	covid restrict restriction stop lockdown start book read learn podcast helpful work diet recover
Eating/Mental Disorders	bulimia anorexia ed purge mental health anxiety disorder issue struggle suffer therapy diagnose
Family Concerns	mom dad sister parent person family habit eating watch see unhealthy food perspective grow life
Treatment	vyvanse adhd take medication doctor prescribe med mg work appetite side effect adderall drug
Addiction Recovery	sober away addiction reward money use app uber delivery drive work pay grocery strategy