Demographic disparities in longitudinal changes in mental health and social connection following the COVID-19 pandemic

Minseong Hong

Abstract: During the COVID-19 pandemic, the overall prevalence of both mental illness and social isolation increased in the United States (US). In this study, we utilized data from the CDC's Household Pulse Survey, which includes hundreds of thousands of responses indicating level of anxiety and depression symptoms and social connection from 2020 to 2024. By analyzing this data, we were able to better understand the mental and social health outcomes of different demographic populations in the US following COVID-19. Leveraging multivariate analysis, we investigated distinct overall and time-specific patterns in demographic clusters' responses. Results consistently indicated that those who are older, more highly educated, cisgender, and heterosexual were less likely to display anxiety, depression, and loneliness during and since the pandemic. In contrast, those who are younger, less educated, from Southern states, and from certain communities of color showed a greater level of overall anxiety, depression, loneliness, and lack of support. Notably, those who are LGBT and disabled had the highest rate of mental health symptoms and self-perceived isolation at the end of the survey. Furthermore, throughout the study, all populations with greater prevalence of anxiety and depression were also more likely to indicate feelings of loneliness and lacking support, and vice versa. This co-occurrence suggests that self-perceived social isolation may have been associated with greater mental burden during the pandemic. All in all, these results call into importance increased support for identified vulnerable populations following COVID-19, as well as during similar future crises.

Keywords: COVID-19 pandemic, United States, mental health, social connection, public health

Introduction

The COVID-19 pandemic had a significant impact on every aspect of American's lives. After being declared an international public health emergency by the World Health Organization[1] on January 30, 2020, Americans quickly found their everyday routines being upended as jobs and schools went virtual, state governments passed stay-at-home orders, and once commonplace in-person social interaction became a health risk[2,3]. These events undeniably took a toll on the mental health of Americans; in 2020, at the height of the COVID-19 pandemic, the overall proportion of US adults with depression symptoms had more than tripled from pre-pandemic levels to 27.8%[4].

The relationship between social connection and mental health has already been well-established. Social isolation has been linked to increased risk of developing depression and overall poorer mental health, while social connection has been associated with improved mental well-being, recovery from mental illness, and even longer lifespan[5,6].

During COVID-19, governments passed policies to prevent the virus' spread through person-to-person contact that forced individuals to stay indoors for longer periods of time and interact less frequently with others[2]. Overall, this led Americans to report a decline in the quality of their relationships[7] and an increase in levels of loneliness[8]. Thus, in addition to various other stressors, deprivation of the "fundamental human need" of social connection experienced during

COVID-19 was no doubt a factor in overall Americans' worsened mental health outcomes[5]. Provingly, it has been found that "those who expressed feelings of social isolation due to COVID-19 were 3 times more likely to meet the threshold score for depression"[9].

Those who already lacked support and were isolated pre-pandemic may have especially been at risk. Previous literature has identified several populations with worse mental health outcomes during COVID-19, primarily those who are Latino and Hispanic, lower income, and younger[9,10]. These disparities may have been caused in part by greater exposure to stressors, for example, economic instability, lack of access to healthcare[11], and, for Latino and Hispanic communities in particular, disproportionate COVID-19 infection rates and unemployment levels[9]. However, research connecting social connection in particular with demographic disparities in mental health outcomes during the pandemic is currently limited.

Altogether, this calls into necessity a comprehensive investigation into demographic patterns of COVID-19 social and mental health outcomes. Thus, in this study, multivariate analysis was utilized in order to identify populations with similar social connection and mental health indicators during and after COVID-19. With this, the aim was to better understand the occurrence of social connection and mental health symptoms in different demographic groups; which populations would benefit most from additional resources during future isolating public health crises; and, by finding similarities between multiple populations, how to create more efficient assistance by targeting several vulnerable groups at once.

Methods

Data Collection

Data used in this study came from publicly available data sets from the National Center for Health (CDC)'s Household Pulse Survey (HPS). Conducted from April 2020 to September 2024, the HPS was designed to assess the impact of the COVID-19 pandemic on Americans. The survey was distributed online to adults aged 18 and over in the US, and the response rate ranged from 1.3 to 10%, with 39,449 to 118,897 responses per two-week time period[12]. Data from two survey topics, "Indicators of Anxiety or Depression Based on Reported Frequency of Symptoms During Last 7 Days" and "Lack of Social Connection", were utilized in this study.

The HPS underwent several changes throughout the process of being conducted. Demographic questions regarding gender identity, sexual orientation, and disability were only added beginning in 2021, while the survey topic "Lack of Social Connection" was only added beginning in 2024. These gaps in data were taken into account throughout the analysis process.

Variables and Measurements

The HPS measured anxiety and depression levels by asking respondents to indicate the frequency of anxiety and depression symptoms they had experienced in the past seven days. Survey data reports the percentage of respondents within each demographic group with a combined symptom score of 3 or higher for anxiety, depression, or both during each time period. Demographic categories included age, sex, gender identity, sexual orientation, race/Hispanic ethnicity, education, disability status, state, and the national average[12].

For the Social Connection section, data represents the percentage of respondents within each demographic group reporting specific frequencies of loneliness, social support, and social integration for each time period[13]. For the purposes of this study, data from questions measuring similar social connection features were grouped together. Responses indicating infrequent communication with family, friends, or neighbors through calls, texts, or messages were summarized as “Low virtual contact”, while responses indicating infrequent attendance at religious services, clubs, or organizations were summarized as “Low org attendance.”

Data Analysis

Unsupervised hierarchical clustering in Phase 1

To account for differences in temporal coverage, demographic groups for which data was only gathered in later time periods were clustered separately. For each feature, values were standardized across demographic groups using z-score transformation. Pairwise similarity between demographic groups was calculated from the standardized feature matrix using cosine similarity (`lsa::cosine`). Cosine similarities were transformed into distances, and agglomerative hierarchical clustering was performed using Ward's linkage (`stats::hclust`, method = `"ward.D2"`). Seven clusters were selected based on evaluation of cluster separation across candidate cluster numbers.

Time-trajectory feature extraction in Phase 2

In order to identify temporal response patterns rather than overall response profiles, a trajectory was constructed for each demographic group’s responses to each question throughout the survey. Each trajectory was summarized by eight features: **baseline**, defined as the value at the first available time period; **final value**, defined as the value at the last time period; **mean value** across time period; **peak value** and **peak time**, representing the maximum value and the time period at which it occurred; **area under the curve (AUC)**, or the cumulative value of responses across time periods; **recovery**, defined as the difference between peak and final values; and **variability**, defined as the standard deviation across time periods. Altogether, these trajectory features provided a comprehensive representation of the magnitude, timing, cumulative level, and variability of each demographic group’s responses.

K-means clustering of time-trajectory features in Phase 2

Trajectory features from all indicators were concatenated to construct a demographic group-by-trajectory-feature matrix. Each trajectory feature was standardized across demographic groups using z-score transformation, followed by principal component analysis (PCA). K-means clustering (`stats::kmeans`) was applied to the standardized trajectory-feature matrix to identify demographic groups with similar response trajectories. The initial number (k=6) of clusters was determined by examining the within-cluster sum of squares across candidate values of *k*. UMAP was subsequently performed using the PCA representation to visualize the resulting clusters.

Cluster 2.1 was merged with Cluster 2.2 because Cluster 2.1 contained only a single demographic group and overlapped with Cluster 2.2 in the UMAP visualization of the original six clusters. Finally, this resulted in five (k=5) final trajectory clusters (Clusters 2.2–2.6).

Cluster markers

Cluster-specific features were identified for Phase 1 and 2 clusters using the Wilcoxon rank-sum test (`stats::wilcox.test`, `exact = FALSE`) by comparing the standardized feature values of demographic groups within each cluster (x1) against those of all remaining clusters (x2). Features with $P < 0.05$ were considered significant and ranked using a combined score, $-\log_{10}(P) \times |\text{mean difference}|$, which incorporates both statistical significance and effect size. The top-ranked features were used to characterize each cluster.

Results

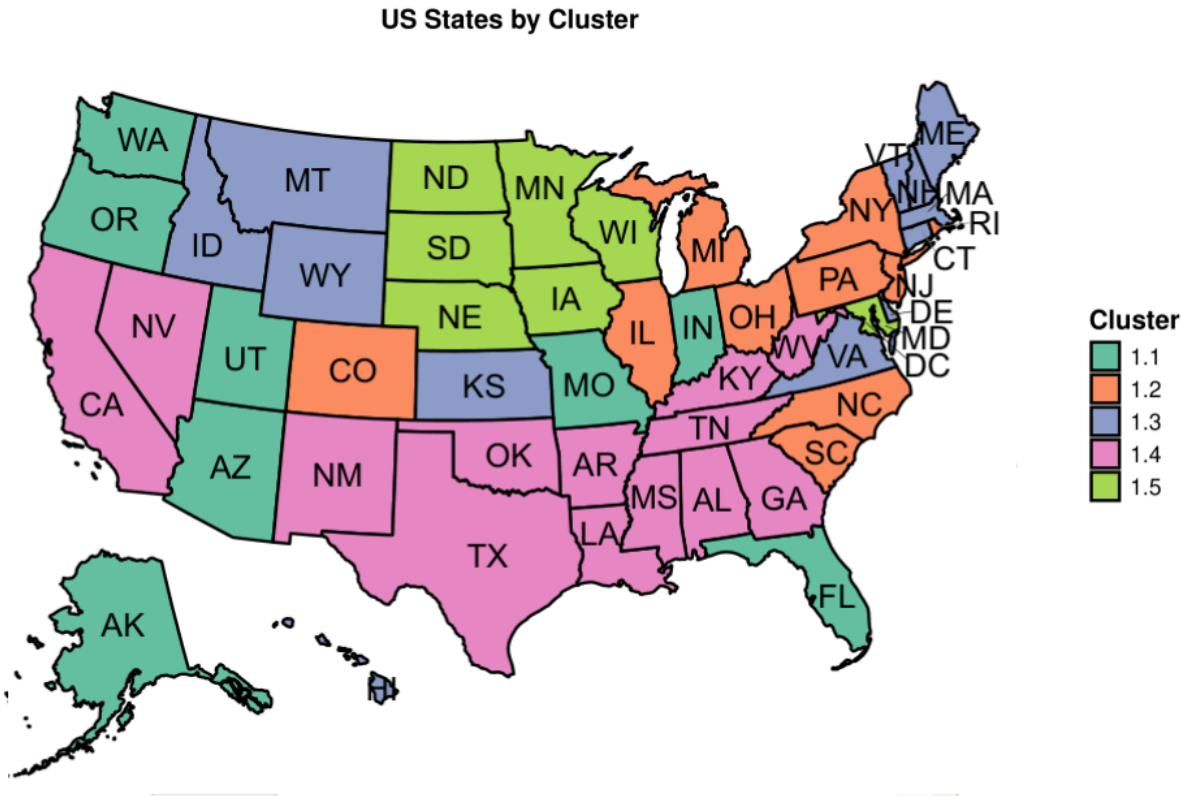
Data used in this study's analysis came from the CDC's Household Pulse Survey (HPS). In the HPS, questions regarding social and mental health were asked beginning in April 2020, during the first months of the COVID-19 pandemic in the US, all throughout September 2024, years after its peak[12]. Responses were separated into two week time periods.

Data from the HPS reports what percentage of demographic populations surveyed reported a certain frequency of mental health symptoms, loneliness, lack of social and emotional support, and types of social interaction during each time period. For more details on the HPS, refer to the Methods section.

Phase 1: Overview of demographic patterns of mental and social health

In Phase 1, we performed an analysis of 78 demographic groups with similar responses to 12 questions for an overview of the mental and social health of different populations throughout the time the survey was conducted. After feature normalization, we performed K-means unsupervised clustering and identified 5 groups with similar patterns of responses at each time period. Disability, gender, and sexual orientation related demographics were clustered separately due to data for these groups only being available from limited time periods, resulting in 2 more clusters.

Figure 1 | Geographic and demographic make up of Clusters 1.1–1.7. Clusters 1.6 and 1.7 are not represented in the US map due to being clustered separately, not including geographic characteristics.



Cluster 1.1: Dispersed states.

Cluster 1.2: 50-59 years; Middle Atlantic and Midwestern states.

Cluster 1.3: White; New England and Mountain states.

Cluster 1.4: 18-49 years old; Associate's degree, some college, or less; Female; Hispanic, Latino, Black, or other/multiple races; Southern states; US Average.

Cluster 1.5: 60-89 years old; Bachelor's degree or higher; Male; Asian; Great Plains states.

Cluster 1.6: No disability; Cisgender; Straight.

Cluster 1.7: Disabled; LGBT.

Clusters 1.1-1.5 are largely defined by state data. Although Cluster 1.1 contains states dispersed across the US, others are geographically concentrated– Cluster 1.2 is primarily made up of Middle Atlantic and Midwestern states with dense urban areas; 1.3, New England and Mountain states; 1.4, the South; and 1.5, the Great Plains region[14].

Clusters 1.4 and 1.5 are also particularly influenced by non-geographic data, and their demographic makeup appears to be in direct contrast to one another. Cluster 1.4 is made up of

those below 50, Cluster 1.5 those above 60; 1.4 contains those who have received less high school and college education, 1.5 those who have a Bachelor's degree or higher. Notably, racial minority groups are also grouped in with these clusters—Cluster 1.4 includes those who are Hispanic or Latino, Black, and Other or mixed races, and Cluster 1.5, those who are Asian.

Clusters 1.6 and 1.7, clustered separately, also contain opposite demographic traits. Cluster 1.7 can be seen as a minority group, including those who are LGBT and those with disabilities; in comparison, Cluster 1.6 is made up of those who do not have disabilities and are heterosexual or cisgender.

Anxiety and depression related features for Phase 1 clusters

After 7 clusters were found, in order to better understand each's unique mental health outcomes, survey time periods with responses indicating a rate of anxiety and/or depression symptoms that most distinguished each from the others were identified using a Wilcoxon rank sum test. The same test was performed for Clusters 1.1-1.5, then separately for 1.6 and 1.7.

Figure 2A | Bubble plot for indicators of anxiety and/or depression for Clusters 1.1-5. For all bubble plots, * represents a p value less than 0.05, ** less than 0.01, and *** less than 0.001.

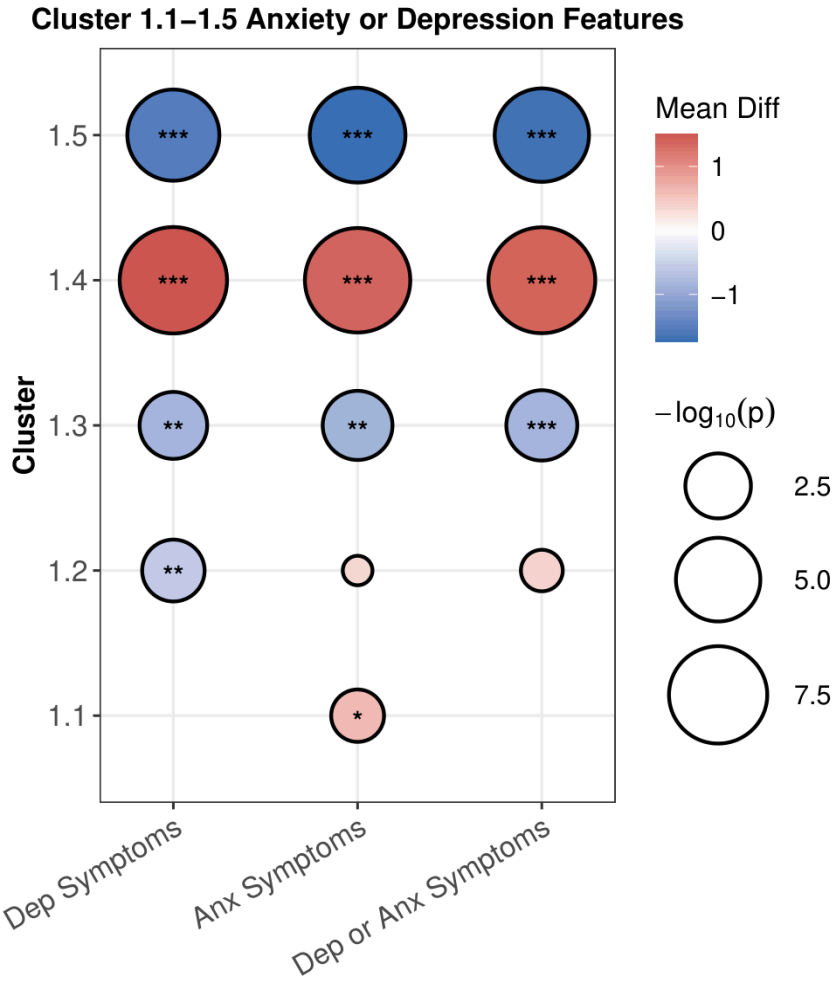
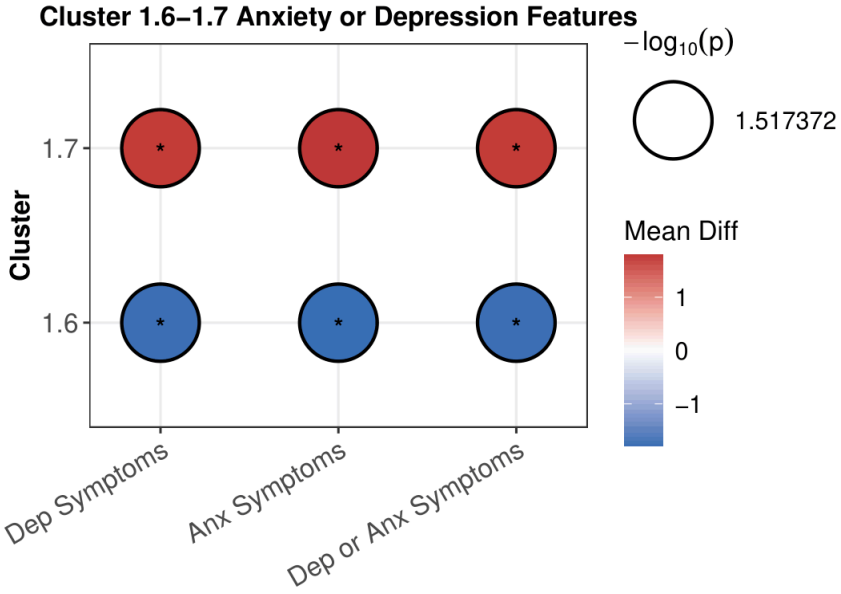


Figure 2B | Bubble plot for indicators of anxiety and/or depression for Clusters 1.6-1.7.



Overall, statistically significant (p value < 0.05) anxiety and depression features appear to be generally homogenous—clusters with higher rates of depression symptoms also display higher rates of anxiety symptoms, and vice versa. Clusters significantly impacted by non-geographic data show the most distinct responses, with Cluster 1.4 having much higher rates of symptoms and Cluster 1.5 much lower compared to other groups. Similar to Cluster 1.5, 1.3 also displays less anxiety and depression, although to a more moderate extent.

Analysis of Clusters 1.6 and 1.7 results in the finding that Cluster 1.6 displayed significantly lower levels of anxiety and depression compared to 1.7; however, as they were clustered separately, these groups cannot be compared to Clusters 1.1-5.

Social connection related features for Phase 1 clusters

Similar to how anxiety and depression features were found, distinct responses at different time periods to social connection questions were identified using the Wilcoxon rank sum test for Clusters 1.1-1.5, and then 1.6-1.7.

Figure 3A | Bubble plot for indicators of social connection for Clusters 1.1-5.

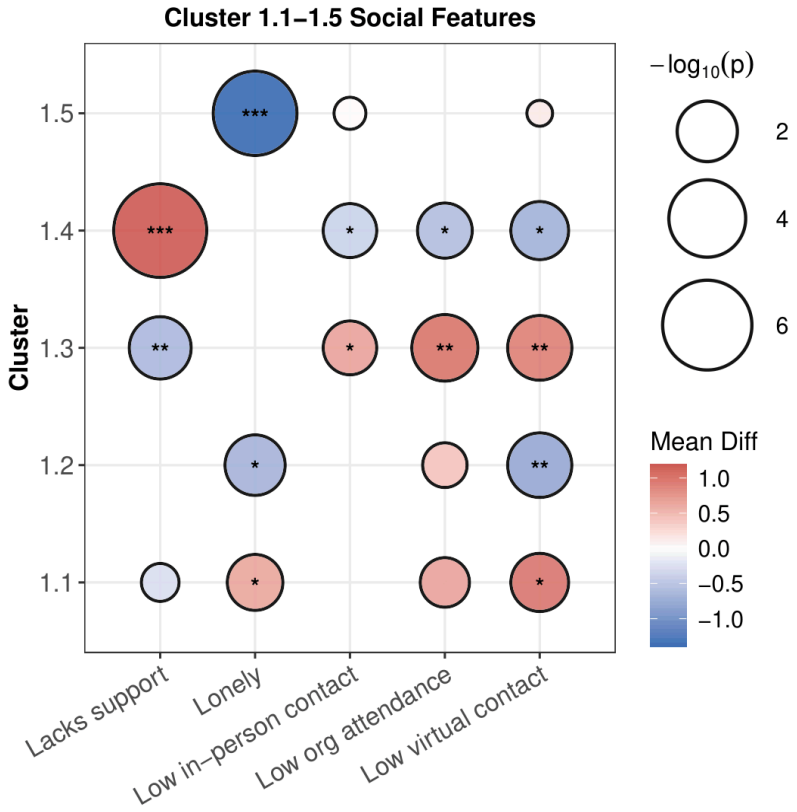
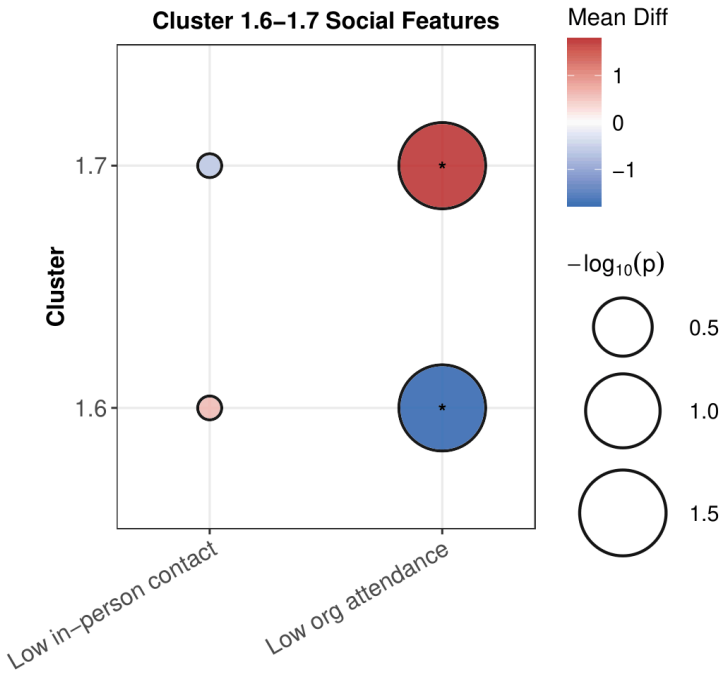


Figure 3B | Bubble plot for indicators of social connection for Clusters 1.6-7.



Compared to anxiety and depression features, social connection features are shown to be much more heterogeneous or varied. Clusters 1.1 and 1.3 both display lower rates of social integration features (or, less frequent social interaction with others). However, while Cluster 1.1 was more likely to indicate loneliness, Cluster 1.3 was counterintuitively less likely to report lacking social and emotional support. Meanwhile, although Clusters 1.2 and 1.4 both indicated greater social integration, those from Cluster 1.2 showed less loneliness while those from 1.4 were significantly more likely to lack social and emotional support. Altogether, these results reveal the complexity of the relationship between frequent interaction with others and social health—just because one scored highly on social integration as defined by the survey did not mean they felt properly supported and did not feel lonely, and vice versa.

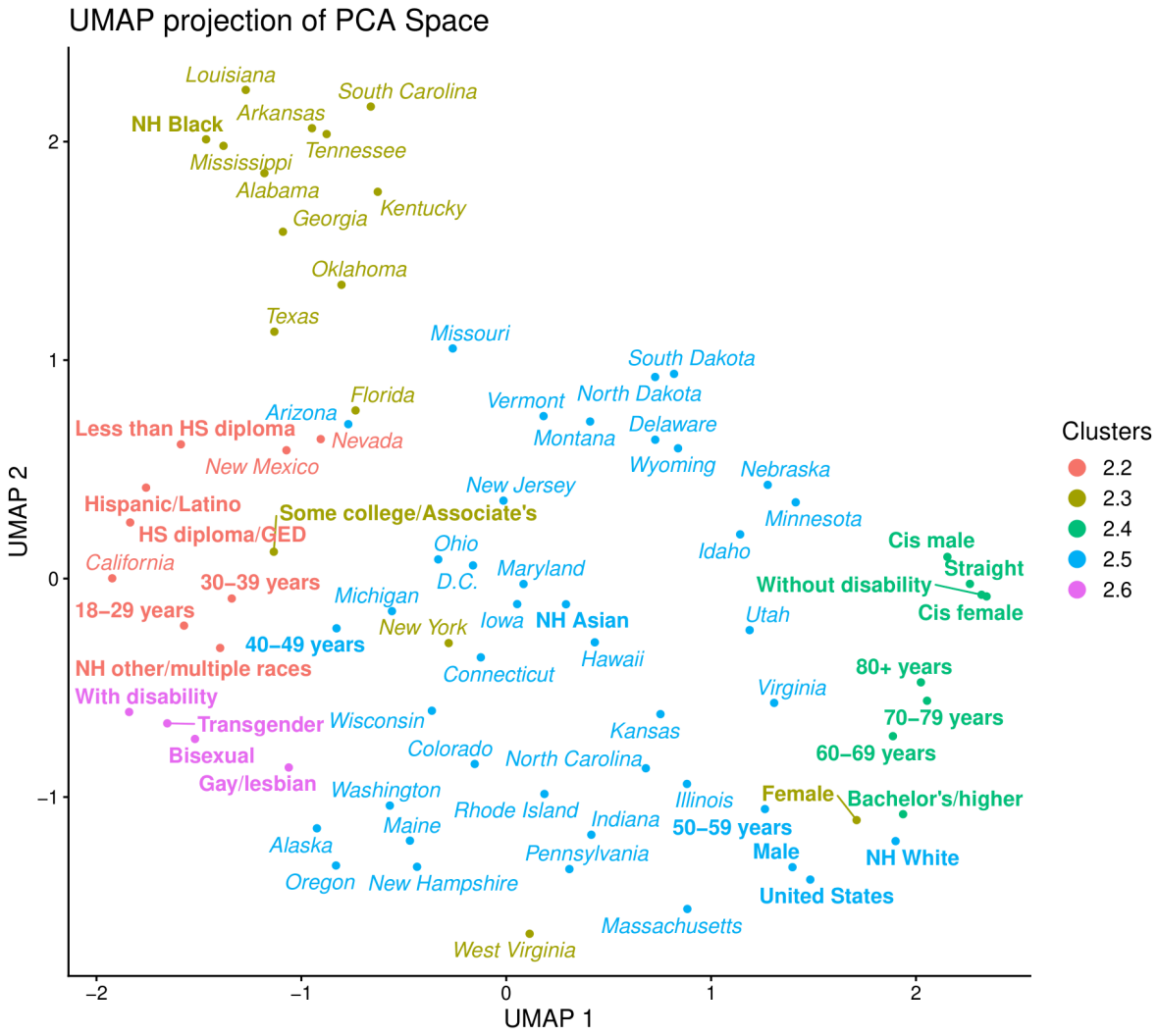
All in all, based on social and mental health related features for Phase 1 clusters, there appears to be a co-occurrence of indicators for anxiety and depression and social connection between clusters, particularly for questions related to loneliness and socioemotional support. Clusters 1.1 and 1.4, which displayed higher rates of anxiety and/or depression, had more respondents who were lonely or lacked support, and Clusters 1.2, 1.3, and 1.5, with lower rates of anxiety and/or depression, had lower rates of loneliness or lacking support as well. Likewise, Cluster 1.7 displayed higher rates of anxiety and depression alongside lower rates of attendance at social clubs, and the opposite was the case for Cluster 1.6.

Phase 2: Demographic Patterns in the Trajectories of Anxiety, Depression, and Social Connection Responses Over Time

After identifying seven clusters of demographic groups with similar mental health and social connection profiles, in Phase 2, we examined how these groups' responses had changed over the course of the pandemic. By doing so, our goal was to identify distinct risk trajectories for each population, including those who were more resilient against mental illness and isolation throughout, those who were consistently vulnerable, and those who initially suffered, and then had high rates of recovery.

Using the same feature matrix as in Phase 1, we summarized the overall trajectory of responses each demographic group had to each question through several features. These trajectory features included the initial value, peak value, peak value time point, cumulative burden (auc), final value, recovery, and variability (see Methods). K-means clustering of the resulting trajectory-feature matrix identified five distinct clusters, representing demographic groups that shared similar temporal patterns of mental health burden and social connection over the course of the pandemic.

Figure 4 | UMAP visualization of PCA analysis and demographic makeup of K-means trajectory feature clustering results (Clusters 2.2-2.6).



Cluster 2.2: 18-39 years old; Western states; HS diploma, GED, or less; Hispanic, Latino, or other/multiple races.

Cluster 2.3: Southern states; Black; Female; Some college or Associate's degree.

Cluster 2.4: 60-89 years old; Bachelor's degree or higher; Cis-gender; Straight; With disability.

Cluster 2.5: 40-59 years old; Dispersed states; US average; Asian and White.

Cluster 2.6: LGBT; With disability.

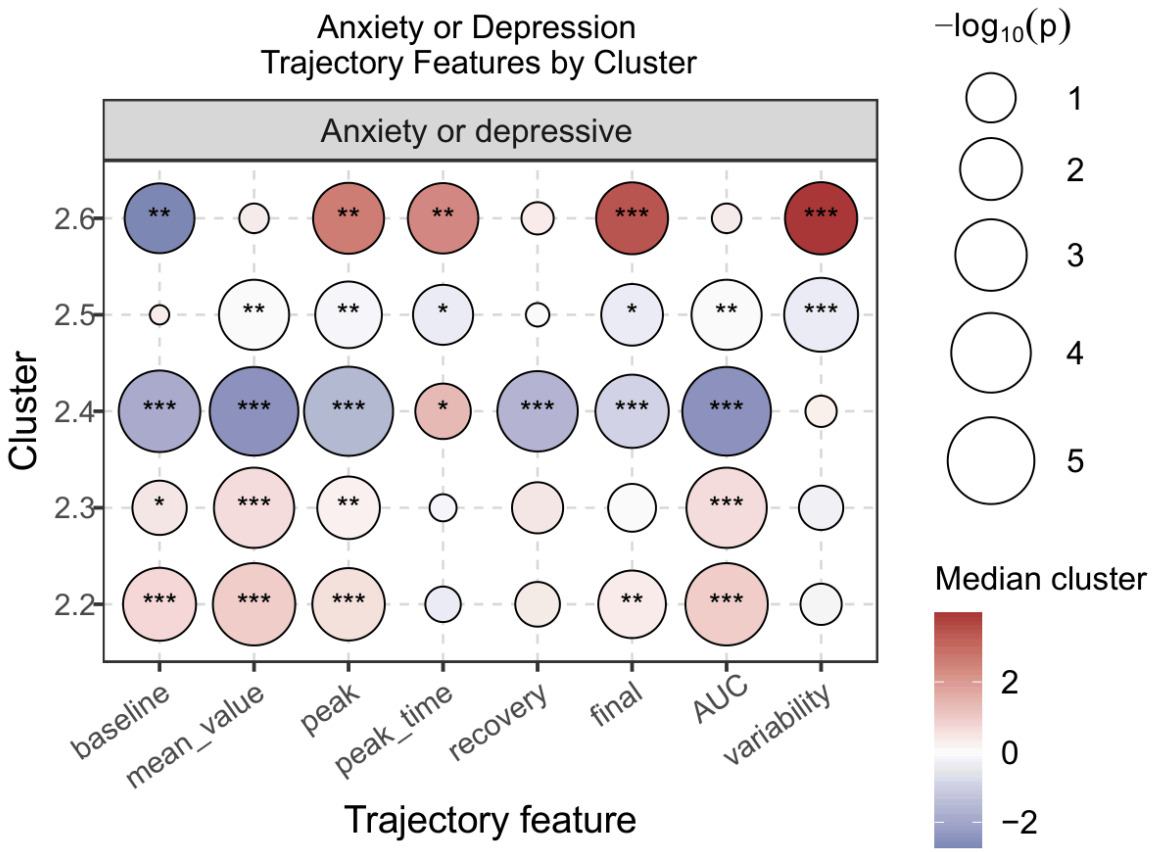
Overall, feature trajectory clusters are somewhat consistent with those identified in Phase 1, with some distinctions. Populations grouped in Cluster 1.4 from Phase 1 were divided in Phase 2 into Clusters 2.2 and 2.3—Cluster 2.2 including those who are younger, Hispanic, Latino, or Other/mixed race, and have a HS diploma, GED, or less, and Cluster 2.3 containing the same Southern geographical location as Cluster 1.4, in addition to those who are Black and have some college/an Associate's degree. The separation of these demographic groups into different

clusters in Phase 2 suggests that although their overall rate of responses may have been similar, their trajectories were distinct. Meanwhile, Cluster 2.4 combines older and more educated groups from Cluster 1.5, as well those who are cisgender, heterosexual, and without disability from 1.6. Cluster 2.6's composition, made up of those who are LGBT and disabled, is identical to Cluster 1.7's.

Finally, Cluster 2.5 is by far the largest cluster, made up of those who are middle aged, as well as many of the states originally dispersed amongst Phase 1 clusters. In general, geographical location does not differentiate Phase 2 clusters as much as they did in Phase 1, with many states separated in Phase 1 grouped together in the same clusters in Phase 2. This suggests that non-geographical traits more strongly distinguish response trajectories.

Following clustering, notable feature markers for each cluster were once again found through a Wilcoxon rank sun test, this time in regards to which trajectory markers were the most distinct. The results were then visualized.

Figure 5A | Bubble plot for anxiety and depression trajectory feature markers for Clusters 2.2-2.6. Due to data for all demographic groups in Cluster 2.6 and some in 2.4 only being available for a limited time period, baseline, mean value, peak time, variability, and area under curve (AUC) feature results for these clusters may be unreliable.



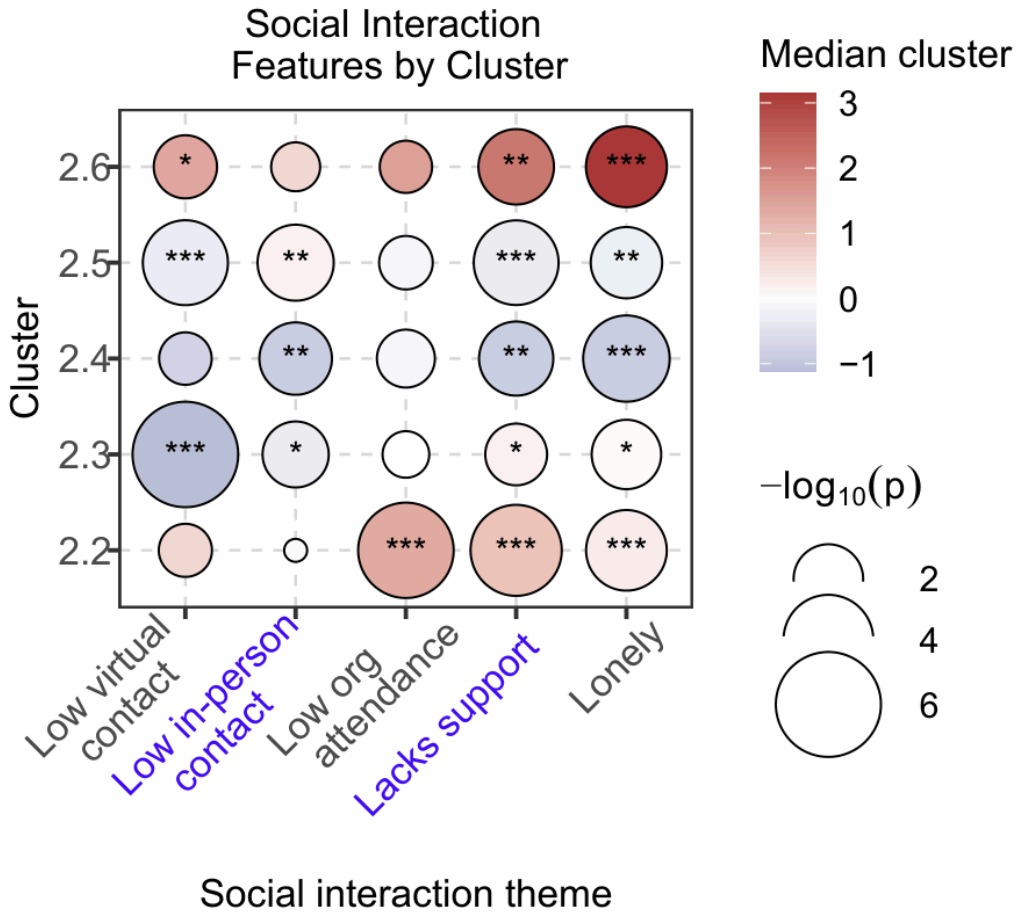
Overall, Clusters 2.2 and 2.3 were found to have higher mean values of anxiety and depression compared to other clusters. These results mirror those of Cluster 1.4, which, as previously discussed, has a similar demographic composition as Clusters 2.2 and 2.3. However, 2.2's overall and final rates of anxiety and depression symptoms were higher than 2.3's, suggesting that while 2.2 and 2.3 were both more impacted by depression and anxiety throughout COVID-19 then other groups, 2.2 experienced greater overall burden that remained even after the pandemic was over.

Cluster 2.6's trajectory features may be somewhat unreliable due to its data being collected for a different time period than the rest of clusters. Nonetheless, its final value—taken at the same time as all other groups—is undeniably the highest of all clusters, suggesting that Cluster 2.6 remains the group with the greatest prevalence of anxiety and depression following COVID-19.

Meanwhile, Cluster 2.4's mean level of anxiety and depression is lowest. This aligns with Cluster 1.5, which Cluster 2.4 has a similar demographic composition as. Cluster 2.4's peak time was also later, suggesting that COVID-19's mental toll had a delayed impact on this population.

Finally, 2.5 experienced less variability in anxiety and depression symptoms compared to other clusters, and differed the least from the average of all responses. Thus, Cluster 2.5 may be seen as a relatively stable cluster that is most representative of the general US population's mental health trajectory following COVID-19.

Figure 5B | Bubble plot for median cluster values of social connection features for Clusters 2.2-2.6. Data for these features was equally present for all demographics, and was gathered from January 9, 2024, to September 16, 2024.



Social connection features for Phase 2 trajectory clusters appear to generally be more homogenous compared to Phase 1 clusters. The exceptions are Cluster 2.5—which shows a greater rate of most social connection features, but is lower for in-person interaction—and 2.3—which shows higher levels of social interaction (particularly virtual contact), but less support.

Furthermore, Phase 2 clusters generally show similar social connection patterns as Phase 1 clusters they have similar demographic compositions to, with some distinctions. Clusters 2.3 and 1.4 both show greater social integration alongside lower support, although the lack of support is more moderate for 2.3. Meanwhile, Clusters 2.4 and 1.5 both display the lowest loneliness levels of all clusters; however, 2.4, unlike 1.5, scores highly on other measures of social health as well.

The co-occurence of mental health symptoms and support and loneliness identified in Phase 1 appears to be reinforced in Phase 2 clusters. Clusters 2.2, 2.3, and 2.6, which were all shown to have greater rates of anxiety and depression at certain timepoints, are also shown to have greater levels of loneliness and/or lack of support. Cluster 2.6 in particular shows extremely high levels of loneliness, presenting it as not only a high-risk group for anxiety and depression following COVID-19, but also poor social health. Finally 2.4 and 2.5, with lower final levels of anxiety and depression symptoms, also show greater levels of support and loneliness.

Discussion

Key Findings

In this study, overall demographic patterns regarding mental and social health in the US were analyzed, as well as trajectories of mental and social health outcomes during and after the COVID-19 pandemic. Several key findings were identified as a result.

Clusters with lower rates of anxiety and depression symptoms from Phase 1 and 2 consistently contained similar demographic makeups of older, more highly educated, cisgender, and heterosexual groups. Similar low-risk populations have been identified in prior research[15,16]. Thus, these characteristics can be viewed as protective factors, making one less psychologically vulnerable to events such as COVID-19.

Meanwhile, demographics with higher rates of anxiety and depression also remained consistent between phases. This included those who are younger, less educated, Hispanic, Latino, Black, Other/multiple races, from Southern states, LGBT, and disabled. In particular, those who are LGBT and disabled were found to have the highest rates of anxiety, depression, and loneliness out of any groups at the end of the survey. Although data for these groups was not available during COVID-19, these results suggest they may have also been at high risk during the pandemic.

These findings are consistent with previous literature on populations especially vulnerable to COVID-19's impact. As previously discussed, a variety of stressors that disproportionately impacted these communities during the pandemic have been identified, including financial burden[17], unemployment[18], lack of access to healthcare[11], higher COVID-19 infection and mortality rates[19], and stigma from minority identity[20].

In this study, however, we specifically analyzed the social connection outcomes of these populations with worse mental health outcomes following the pandemic. As a result, we identified that in addition to other previously identified risk factors, all of these groups were more likely to indicate insufficient social and emotional support and/or feelings of loneliness. In other words, there was a consistent co-occurence of loneliness and lack of support and anxiety and depression features. However, this pattern with mental health symptoms was not always present for other measures of social connection. These results suggest that rather than frequency of interaction with friends, families, and organizations, loneliness and poor self-perceived support may be significant social connection-related predictors of populations at risk of poor mental health during future pandemics.

Limitations

There were several limitations to the data utilized in this study, as well as the methods in which this data was analyzed. As reported by the CDC, the HPS was only conducted with households with an accessible email address or cell phone number, potentially leaving out some groups[12]. Nonresponse bias may have also impacted results. Furthermore, demographic labels utilized in the HPS are not fully comprehensive of social identity and do not account for intersectionality, or the combination of several demographic characteristics at once.

Lastly, the limited time frame in which questions regarding social connection were asked and demographic information on disability, sexual orientation, and gender identity was gathered was a major limitation to the data analysis process, as well as understanding how these factors impacted different demographics' mental health during COVID-19 in particular. Finally, the Wilcoxon marker test utilized to identify feature markers assumes normal distribution, which response data may have not had.

Conclusion

Overall, this study identified several key groups facing social and mental health challenges during and since the COVID-19 pandemic, as well as groups with less burden. Certain communities of color, those living in the South, those who are younger, and those who are less educated were found to have higher rates of mental health symptoms and feelings of isolation during COVID-19. Meanwhile, LGBT individuals and those with disabilities were found to have the greatest persistent burden after the pandemic was over. Conversely, being heterosexual and cisgender, highly educated, and older are all protective factors.

As previously discussed, social connection, emotional support, and relationships with others are crucial in protecting mental health and developing resistance to stressors[5,6]. This association was no doubt especially significant during a global pandemic, when people were forced to be physically isolated, and thus, more likely to be socially isolated as well. Accordingly, all populations identified in this study with higher rates of mental health symptoms during and since COVID-19 were also more likely to later report lacking support and feeling lonely.

Thus, it is recommended that more research be conducted on how populations at risk of being socially isolated can be connected with support groups and mental health resources during similar future events. Virtual communities may be an especially valuable resource, particularly for younger individuals who tend to spend more time online, disabled people who face mobility barriers[21], and LGBT individuals for whom geographic location is a barrier to finding community[22]. Provingly, one study found dissatisfaction with virtual tools for socialization during COVID-19 to be the most significant factor associated with reduced mental and social health for young adults[23].

All in all, this study investigated social connection factors and mental health symptoms in multiple demographic populations following COVID-19. During future global crises, particularly those that are socially isolating, special attention should be given by government organizations to provide the vulnerable populations identified in this study with further mental and social support, ensuring improved overall public health outcomes in the US.

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