Factors associated with county-level mental health during the COVID-19 pandemic

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Abstract
The objective of this study is to determine county-level factors associated with anxiety, depression, and isolation during the coronavirus disease 2019 (COVID-19) pandemic. This study used daily data from 23,592,355 respondents of a nationwide Facebook-based survey from April 2020 to July 2021, aggregated to the week-county level to yield 212,581 observations. Mental distress prevalences were modeled using weighted linear mixed-effects models with a county random effect. These models revealed that weekly percentages of mental distress were higher in counties with higher unemployment rates, populations, and education levels; higher percentages of females, young adults, individuals with a medical condition, and individuals very worried about their finances and COVID-19; and lower percentages of individuals who were working outside the home, living with children, without health insurance, and Black. Anxiety peaked in April 2020, depression in October 2020, and isolation in December 2020. Therefore, United States counties experienced the mental health effects of the pandemic differently dependent upon their characteristics, and mental distress prevalence varied across time.

KEYWORDS
anxiety, counties, COVID-19, depression, education, isolation, sociodemographics
Throughout the duration of the coronavirus disease 2019 (COVID-19) pandemic, symptoms of anxiety and depression have been of key interest. The onset of the pandemic caused a complete lifestyle shift as a result of stay-at-home orders, physical distancing, and mask mandates, as well as worldwide apprehension towards the COVID-19 disease and related financial and other challenges. In the past, most large-scale disasters have led to increases in mental distress levels (Neria et al., 2008), and empirical research has found that the COVID-19 pandemic is no different due to threats to physical health and the effects of social and physical isolation to avoid transmission (Galea et al., 2020; Pfefferbaum & North, 2020).

When investigating the mental health impacts of a broad-reaching traumatic event, researchers often compare distress before, during, and after the event occurs using different nationally representative samples. For the COVID-19 pandemic, one study found that 13.6% of respondents reported serious psychological distress in April 2020 compared with 2.9% of 2018 National Health Interview Survey respondents (McGinty et al., 2020). Another study compared responses from March–April 2020 to 2017–2018 data and found that the prevalence of depressive symptoms reported in the 2020 survey was over three times higher than that in 2017–2018 (Ettman et al., 2020). These studies have shown an overall increase in distress during the pandemic compared with before it began.

Another important perspective when researching the impacts of the pandemic is to look at mental health on the individual level. Although the pandemic is worth investigating on its own as a factor related to mental distress, it is also necessary to consider the relationship between the large-scale event and individual-level stressors that have arisen or worsened due to the pandemic (Richman et al., 2012). During the early months of the pandemic, multiple projects investigated the mental health trajectories of individuals. One paper looking at data from March to August of 2020 found significantly higher odds of mental distress in adults below the poverty line compared with those above it, individuals living in the western United States compared with the southern United States, females compared to males, White individuals compared with Black individuals, and younger adults compared to older adults (Riehm et al., 2021). Another study found higher rates of positive screens for anxiety or depression among younger adults, females, and adults with lower education levels and lower incomes (Cai et al., 2021). Both of these studies also compared changes in rates of distress longitudinally; the first found higher rates of distress in April and May but lower in June and August compared with March 2020, while the second found an overall increase in positive screens from 35.9% to 40.9% from April 23 to July 21 of 2020 (Cai et al., 2021; Riehm et al., 2021).

In other research on factors associated with individual mental distress during the pandemic, significant factors included lower income, exposure to stressors (i.e., financial problems and losing a job), younger age groups, Hispanic ethnicity, food insecurity, and personal health symptoms (Ettman et al., 2020; McGinty et al., 2020; Swaziek & Wozniak, 2020). Individuals reporting disabilities on an online survey collected in the Intermountain Western US also experienced higher levels of COVID-19 stressors, such as increased social isolation and financial constraints, compared to non-disabled individuals (Ciciurkaitė et al., 2021).

To help allocate resources, assist with local planning, and understand the burden of mental distress across the country, it is important to also understand how mental distress varies across geographic areas. Research done before the pandemic has identified key determinants of area-level mental health, including education levels, income, population density, and health at the county-level (Lawless & Lucas, 2011); neighborhood poverty (Leventhal & Brooks-Gunn, 2003; Ross, 2000); and percent Black residents in a neighborhood (Nguyen et al., 2016). During the pandemic, the area-level research that has been done has primarily been outside of the United States. A study in Japan showed that higher urbanization and lower neighborhood socioeconomic status were related to psychological distress during the pandemic, but the number of new COVID-19 cases in the neighborhood was not (Okubo et al., 2021), and a UK study found that school closures were predictive of worse mental health for mothers (Blanden et al., 2021). Additionally, a systematic review across 33 countries noted a lower prevalence of clinically significant depressive symptoms in countries whose governments responded more quickly to the pandemic with lockdown policies (Lee et al., 2021).
There has not been work done specifically in the United States that has focused on geographic area-level, specifically county-level, mental health during the COVID-19 pandemic. Furthermore, previous research on mental health responses to the pandemic is primarily limited to the first few months of the pandemic, despite evidence that mental distress has remained elevated in the general population until 2021 (Keeter, 2021). To address these research gaps, we used an ongoing, national Facebook-based survey of households that can be aggregated to the county level, with data collected on a daily basis since April 6, 2020. Our objective was to use aggregated responses from April 2020 to July 2021 along with census county-level data to assess relationships between county characteristics and county-level symptoms of anxiety, depression, and isolation during the pandemic. We hypothesize that symptoms of anxiety, depression, and isolation will be most prevalent in local areas during spring 2020 and winter 2021 and that they will have a positive association with county-level factors such as COVID-19 cases and deaths, unemployment, population density, and percentages of survey respondents in the county who are female, young adults, living with children and/or older adults, living with medical conditions, and very worried about finances and COVID-19.

2 | MATERIALS AND METHODS

2.1 | The US COVID-19 trends and impact survey

The primary data set used in this study was The Delphi Group at Carnegie Mellon University US COVID-19 Trends and Impact Survey (CTIS), implemented in partnership with Facebook (Salomon et al., 2021). The survey is a daily cross-sectional survey that invites a new stratified random sample of adults (ages 18 + ) on Facebook in the United States to take the survey each day (Salomon et al., 2021; Badiillo-Goicoechea et al., 2021; Barkay et al., 2020). Since April 6, 2020, the survey has gathered about 50,000 respondents daily. Respondents are weighted to adjust to the general population (Barkay et al., 2020). Questions on the survey cover topics such as COVID-19 symptoms, health behaviors, mental health and worries about the pandemic, demographic information, and FIPS code reflecting United States county (Salomon et al., 2021; Badiillo-Goicoechea et al., 2021; Barkay et al., 2020; Kreuter et al., 2020).

In this study, we included all survey respondents from April 6, 2020 to July 31, 2021 who had a nonmissing FIPS code and survey weight. For each week in this time frame, we aggregated to the county level using FIPS code. Some county-level covariates used in the analyses were calculated directly from the Delphi US CTIS survey data. These were: the percentages of respondents in a given county in a week who are female; are in the age groups of 18–34, 35–54, and 55 plus; live with at least one child; live with at least one adult over the age of 65; have a medical condition among a certain list; have worked recently outside of the home; feel very worried about their household’s finances (as opposed to somewhat worried, not too worried, or not worried at all); and feel very worried that someone in their immediate family would become seriously ill with COVID-19 (again as opposed to somewhat worried, not too worried, or not worried at all). All of these percentages were calculated using the Facebook survey weights. These variables and how they changed slightly across the duration of this study are described in Appendix Table A.4). Other key variables pulled from this survey were the response date, the county FIPS code, the number of respondents from the county in a given week, and the weight assigned to each participant by Facebook.

To assess mental health symptoms, we used responses to the following survey questions: “In the past 5 days, how often have you felt nervous, anxious, or on edge?,” “In the past 5 days, how often have you felt depressed?,” and “In the past 5 days, how often have you felt isolated from others?.” The first question was adapted from the GAD-7 (Spitzer et al., 2006) and the second and third from the CES-D (Radloff, 1977). Both of these scales have been previously shown to have high internal consistency (GAD-7: 0.92, CES-D: 0.90) and good test-retest reliability (GAD-7: 0.83, CES-D: between 0.45 and 0.7) (Radloff, 1977; Spitzer et al., 2006). On March 2, 2021, the survey question was changed to instead ask about the past 7 days for all three mental distress variables. Answers to the three questions were on a 4-point scale: (1) None of the time, (2) Some of the time, (3) Most of the time, and (4) All the time. These responses were dichotomized into binary indicators, with 0 indicating a response of “none of the
time," and 1 indicating responses of some, most, or all of the time. From these individual binary indicators, we aggregated to the county level to obtain the weighted percentage of individuals in a county who reported each type of symptom in the past 5 (or 7) days.

2.2 | County-level data

Aside from the above individual-level predictors that were aggregated to the county level, several other county-level predictors were gathered for analysis from the United States Census and other sources. These predictors included the percentage of Black residents in the county, percentage of the county with no health insurance, percentage of adults in the county with a high school degree, county population, county median household income from 2018 (Glenn, 2019), monthly county unemployment rate (US Bureau of Labor Statistics, 2013), county population density from 2010 (Ykzeng, 2020), and United States region (Northeast, Midwest, Southeast, Southwest, or West) (National Geographic Society, 2012). Finally, COVID-19 daily cases and deaths by county were collected and summed to yield cases and deaths per week (USA Facts, 2021). These variables were selected inclusively and with the goal of using variables found to be significant in previous literature (Lawless & Lucas, 2011).

2.3 | Analyses

From each survey respondent’s report of mental distress symptoms, the survey weights were used to find weighted percentages of individuals feeling symptoms of anxiety, depression, and isolation by county by week (Barkay et al., 2020). County weekly weighted percentages were also calculated for all predictors from the CTIS. With all variables prepared for analyses, three linear mixed-effects models were then run using the “bam” function with restricted maximum likelihood estimation from the MGCV package in R (Wood, 2018), where outcomes were the weighted weekly percentage of individuals in a county in a week who experienced symptoms of (1) anxiety, (2) depression, and (3) isolation. Predictors in the models included a factor for each month, the Delphi US CTIS variables and county-level variables described previously, and COVID-19 cases and deaths per county from each week. All continuous predictors were standardized to have mean 0 and standard deviation 1. Models incorporated county random effects and were weighted by the number of respondents per county per week in the CTIS. Results shown in the following section provide coefficients relating county-level factors to levels of mental distress, and statistical tests of whether those coefficients differ from zero.

The models for anxiety and depression used data from April 6, 2020 to July 31, 2021, while the isolation model used data from the time period in which the isolation question was included in the survey, which was from September 8, 2020 to May 19, 2021. All predictors were included in each of the models, with the exception of the percentage feeling very worried about COVID-19 because that was only available at the same time frame as the isolation question. We also ran models stratified by US region (i.e., Northeast, Southeast, Midwest, and Southwest, West); results are presented in Appendix.

3 | RESULTS

From April 6, 2020 to July 31, 2021, 23,592,355 individuals were surveyed in the Delphi US CTIS. These individuals were aggregated to 3,052 unique FIPS codes (counties) since those were all of the FIPS codes included in both the CTIS and the Census data. The data covered 71 weeks across 16 months, leading to a total of 212,581 observations for weekly county measures of anxiety, 212,490 for depression, and 111,434 for isolation. The county weekly sample sizes ranged from 1 to 14,427 individuals per week per county, with an average of 106.8 responses. Table
| Variable                                                      | All counties |          |
|---------------------------------------------------------------|--------------|----------|
| **Grouped individual-level variables from Delphi US CTIS**    |              |          |
| Number of respondents                                         | 106.8 (275.7) |          |
| Weighted percent feeling anxious some/most/all of the time    | 48.5 (19.3)   |          |
| Weighted percent feeling depressed some/most/all of the time  | 42.5 (18.7)   |          |
| Weighted percent feeling isolated some/most/all of the time   | 46.8 (19.2)   |          |
| Percent female                                                | 54.5 (18.3)   |          |
| Percent 18–34 years old                                       | 22.9 (16.2)   |          |
| Percent 35–54 years old                                       | 32.9 (16.8)   |          |
| Percent over 55 years old                                     | 44.1 (19.2)   |          |
| Percent living with children                                  | 43.1 (19.0)   |          |
| Percent living with adults over 65 years old                  | 35.8 (19.5)   |          |
| Percent with a medical condition                              | 58.2 (18.8)   |          |
| Percent very worried about COVID                              | 22.3 (15.1)   |          |
| Percent very worried about finances                           | 21.3 (16.0)   |          |
| Percent worked outside of home                                | 43.4 (19.1)   |          |
| **County-level variables from US census and other sources**  |              |          |
| Percent Black                                                 | 9.1 (14.5)    |          |
| Monthly unemployment rate                                     | 7.2 (3.7)     |          |
| Percent with no health insurance                              | 10.0 (5.0)    |          |
| Percent with high school degree                               | 86.6 (6.2)    |          |
| Population                                                    | 106,739.2 (335,743.3) |    |
| Median household income                                       | $51,574.4 ($13,652.1) |    |
| Population per square mile                                    | 264.0 (1,752.7) |    |
| **COVID-19 spread**                                           |              |          |
| COVID-19 cases                                                | 162.1 (868.4) |          |
| COVID-19 deaths                                               | 2.8 (17.4)    |          |
| **United States region**                                     | N (%)        |          |
| Southeast                                                     | 1081 (35.4%)  |          |
| Midwest                                                       | 1028 (33.7%)  |          |
| West                                                          | 365 (12.0%)   |          |
| Southwest                                                     | 361 (11.8%)   |          |
| Northeast                                                     | 217 (7.1%)    |          |

Abbreviations: COVID-19, coronavirus disease 2019; Delphi US CTIS, Delphi Group at Carnegie Mellon University US COVID-19 Trends and Impact Survey.
displays summary statistics for key variables aggregated to the weekly county level. With missing mental distress outcomes removed, all predictors had less than 1% missing, so missing values on predictors were also removed for analyses.

From Table 1 we see that the average weighted percent mentally distressed for each variable ranged from 42.5% to 48.5% with relatively large standard deviations of 18.7%–19.3%. On average, the weekly county samples were majority female and over 55 years old, and an average of 22.3% of people in a county in a week said they were very worried that they or someone in their immediate family might become seriously ill with COVID-19. Furthermore, of the total number of counties, 35.4% are in the Southeast, 33.7% in the Midwest, 12.0% in the West, 11.8% in the Southwest, and 7.1% in the Northeast region of the country.

Figure 1 displays the weekly weighted percentage of individuals who felt anxious, depressed, or isolated at all, averaged across all counties. The percentages of individuals feeling symptoms of anxiety and isolation were higher than the percentage of individuals feeling symptoms of depression throughout the whole year. The percentage of individuals reporting symptoms of anxiety peaked in April 2020, October 2020, and January 2021, while depression percentages seem to remain relatively consistent with higher points in May and December of 2020, and isolation percentages peaked in January and February of 2021. After February 2021, the prevalence of all three mental distress outcomes decreased, with the exception of an increase in anxiety in July 2021.

Different regions of the United States also experienced different levels of mental distress during the pandemic, as shown in Figure 2 and Appendix Figure A.1. Graphically, Figure 2 shows that counties in the Midwestern region of the country had lower average weighted percentages of individuals feeling anxious, depressed, and isolated across the entire time period of this study, while the Western and Northeastern regions had higher percentages of mental distress. Regression models confirm this observation; specifically, counties in the Northeast, Southeast, and West all had significantly higher percentages of feeling mentally distressed compared with counties in the Midwest, and the Southwest had significantly higher percentages feeling anxious and depressed compared to the Midwest according to the coefficients and their corresponding t-statistics and p-values from the models fit using restricted maximum likelihood estimation (REML) (Appendix Tables A.1–A.3).

Figure 3 presents a summary of the mixed-effects model results indicating the associations between county characteristics and mental distress (detailed results in Tables A.1–A.3). The coefficients for months show that the percentages of individuals reporting symptoms of anxiety were highest in April 2020 (the reference month),
symptoms of depression in October 2020, and symptoms of isolation in December 2020 after controlling for the other predictors in the model. For all three mental distress outcomes, county-level mental distress was found to be higher across counties based on some demographic factors such as higher percentage of females, a higher percentage of young adults, higher percentage with a medical condition, a lower percentage living with children, and lower percent Black. In addition, county-level factors such as a higher percentage of the county with a high school degree, larger population and population density, higher monthly unemployment rate, and a lower percentage of the county without health insurance were associated with higher percentages of individuals feeling anxious, depressed, and isolated. Higher numbers of weekly cases and deaths also showed associations with higher levels of county-level mental distress. The percentage of individuals working outside the home was negatively associated with distress, while the percentage very worried about finances had a positive association with distress. For the isolation model, a higher percentage feeling very worried about COVID-19 was associated with a higher percentage feeling isolated. Finally, counties in any region compared to the Midwest had higher levels of mental distress.

To translate these coefficients from their standardized form, we illustrate how the coefficients relate to the prevalence of distress for a few of the county-level factors. In the anxiety model, a coefficient of 0.014 (95% confidence interval [CI]: (0.012–0.016)) for the percent of respondents aged 18–34 indicates that for every standard deviation larger in the percentage in this age group, which corresponds to 16.2%, the weekly weighted percent anxious in that county was expected to be 1.4% higher. As another example, 16% higher in the percentage in a county in a week feeling very worried about finances was associated with an average of 1.5% higher percentage feeling depressed ($B = 0.015$, 95% CI: (0.015–0.016)). Finally for the isolation model, for every 15.1% more individuals feeling very worried that someone in their immediate family might become very ill with COVID-19, the percentage feeling isolated was expected to be 1.1% higher ($B = 0.011$, 95% CI: (0.011–0.012)).

Finally, sensitivity analyses were conducted to explore whether counties in different regions of the country had different model results. Linear mixed-effects models were performed, including data from one region at a time. The
coefficients and their 95% confidence intervals are included in Appendix Tables A.1–A.3. Overall, models stratified by region generally showed similar associations as reported for the country as a whole.

4 | DISCUSSION

This article provides a 16-month analysis of the mental distress levels of nearly every county in the United States, shedding light onto relationships between mental distress and county characteristics, COVID-19 spread, and time period. To our knowledge, this paper is the first to look at regional mental health in the United States across the majority of the pandemic’s time span.

Altogether, we found that the percentage of respondents reporting symptoms of anxiety, depression, and isolation varied across the study period, each peaking at a different time. Furthermore, these mental distress outcomes were related to county factors like gender, age, and racial makeup, as well as unemployment and health insurance rates, education, income, and COVID-19 cases, deaths, and worries. These results are largely consistent with the individual mental health literature during the pandemic; namely, higher percentages of females, young adults, and White individuals were associated with higher percentages of mental distress, as found in Riehm and
colleagues’ and Cai and colleagues’ paper (Cai et al., 2021; Riehm et al., 2021). Higher percentages of individuals with medical conditions per county were also associated with higher percentages of mental distress, which aligns somewhat with the literature on increased distress in the disabled community, although this question does not specifically ask about disability (Ciciurkaite et al., 2021). However, while Cai’s study found that lower education levels were associated with higher distress, the present analysis found that higher percentages of adults with high school degrees were associated with higher distress. The monthly trends were relatively consistent with previous work, except for higher percentages of depression in August compared with April 2020 when all variables were controlled for. These results confirm that there are many variables that have a similar relationship with mental distress both at the individual level and county level but also highlight some differences at the county level that support the need for analyzing distress through a broader regional approach.

Our results generally aligned with our hypotheses, with the exception that higher percentages of individuals living with children or living with older adults per county per week were associated with lower distress levels (or had a close to null relationship). Additionally, lower percentages of individuals without health insurance in the county were associated with higher distress levels. This relationship could be indicative of county-level political culture or experiences with healthcare. These results were somewhat surprising and could demonstrate that there are other underlying county-level factors that might be involved in these relationships with distress. It is also important to note that these area-level conclusions cannot necessarily be interpreted as relating to individual household relationships due to the ecological fallacy (Piantadosi et al., 1988).

Measuring factors at a national level is challenging, and one limitation of this study is that the variables may vary in their reliability and validity. Specifically, the variables used from census data and other external sources are primarily from 2018, so some data could have changed over the past couple of years. While the Delphi US CTIS represents a very large-scale national survey, the respondents may not be fully representative of the entire country. The survey weights provided help address this issue but may not solve it entirely. Another limitation of the Delphi US CTIS is that many counties have very small weekly sample sizes, so the results could be noisy. We weighted the mixed-effects models by county weekly sample size to minimize this problem, so results were therefore weighted more heavily towards counties with large sample sizes. Counties with larger weekly sample sizes most likely are counties with larger populations overall, so this means that the model results are skewed towards large, often urban counties. However, these models do cover the entire country at some level, including over 23 million individual responses, so every area of the country is represented. Finally, the mental health data from the CTIS was self-reported, which may have caused some biases and inaccuracies. Certain demographic groups might have been less likely to report feelings of anxiety, depression, and isolation, for example. Future research could look at regional mental distress levels using mental health service utilization, diagnoses, or other indicators.

With social distancing, quarantining, illness, and overall changes in lifestyle, the pandemic has induced mental distress in some segments of the general population that has persisted to the present time (Thombs et al., 2020). Modeling county-level mental distress allows us to learn more about the context of individual mental health across the country. Stress can fall on a continuum from the micro-level to the macro-level, and it is important to look at stress experiences on not only both ends of the spectrum but also along with the range in between (Brown et al., 2018; Wheaton et al., 1994). This study addresses the meso-level stress experience by assessing county-level mental health to help identify regions of the country where mental health might have been more impacted by the pandemic at certain time periods and highlight factors related to mental distress at the county level. Future studies may consider examining counties that have high unemployment rates, populations and population densities, percentages of female and young adult residents, high worries about the pandemic and finances, and more, as those counties are likely to have higher percentages of mentally distressed residents that could benefit from interventions or positive messaging about mental health during the pandemic. Furthermore, given the associations between unemployment and financial worries and mental distress, interventions aimed at countering the economic impacts of the COVID-19 pandemic are also warranted. Finally, it would be worth performing similar investigations in relationship to different large-scale disasters or looking into previous work to determine which county-level factors
related to mental distress might be unique to COVID-19 (i.e., those related to social distancing or with health conditions leading to higher risk) and which factors are more likely to be universally impactful (i.e., unemployment and demographics).

5 | CONCLUSION

Although the public health response to the COVID-19 pandemic has primarily been focused on protecting physical health and preventing mortality, studies have shown that the general population in the United States has experienced significant mental health consequences. The link between physical health and mortality during the pandemic is clear, but we also must consider the link between mental health and mortality which we often overlook (Galea & Ettman, 2021). This connection underscores the need to understand the mental health implications of the pandemic and accurately target interventions to the most impacted communities. Therefore, investigating mental distress across regions and its relationships to sociodemographic factors is vital to identifying different subpopulations of the country that might be facing a mental health crisis that we should address to deal with mental health-related consequences and mortality. This paper assesses county-level public health during the pandemic, which has not been thoroughly studied, specifically in terms of mental health. With further understanding of the mental health experiences across the country, we can better address the negative impacts of the pandemic and help enhance public health.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from The Delphi Group at Carnegie Mellon University. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the author(s) with the permission of The Delphi Group at Carnegie Mellon University.

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PEER REVIEW

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**SUPPORTING INFORMATION**

Additional supporting information may be found in the online version of the article at the publisher’s website.

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