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Persistent depressive symptoms during COVID-19: a national, population-representative, longitudinal study of U.S. adults

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Summary

Background The COVID-19 pandemic and its consequences have been associated with an increase in poor population mental health. We assessed how depressive symptoms changed among U.S. adults over the course of the COVID-19 pandemic and identified the key risk factors for these symptoms.

Methods Longitudinal panel study of a nationally representative group of U.S. adults ages 18 years and older surveyed in March-April 2020 (Time 1; N=1441) and March-April 2021 (Time 2; N=1161) in the COVID-19 and Life Stressors Impact on Mental Health and Well-being study (CLIMB). The Patient Health Questionnaire-9 (PHQ-9) was used to define elevated depressive symptoms (cut-off ≥10) and depressive symptoms score (0-27).

Findings The prevalence of elevated depressive symptoms persisted from 27.8% in 2020 (95% CI: 24.9, 30.9) to 32.8% in 2021 (95% CI: 29.1, 36.8). Over time, the central drivers of depressive symptoms were low household income, not being married, and experiencing multiple stressors during the COVID-19 pandemic. The odds ratio of elevated depressive symptoms for low income relative to high income persons increased from 2.3 (95% CI: 1.2, 4.2) in 2020 to 7.0 (95% CI: 3.7, 13.3) in 2021. Fewer people reported experiencing 4 or more COVID-19 stressors in 2021 than in 2020 (47.5% in 2020 vs 37.1% in 2021), but the odds ratio of elevated depressive symptoms associated with 4 or more stressors relative to 1 stressor or less increased from 1.9 (95% CI: 1.2, 3.1) in 2020 to 5.4 (95% CI: 3.2, 9.2) in 2021.

Interpretation The burden of depressive symptoms in the U.S. adult population increased over the course of the COVID-19 pandemic. Mental health gaps grew between populations with different assets and stressor experiences during the COVID-19 pandemic.

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Keywords: Depression; Mental Health; Economic inequities; Stressors; Low-income; Wealth

Introduction

The COVID-19 pandemic has been associated with a substantial increase in mental illness. U.S. adults reported an estimated three-fold increase in the prevalence of elevated depressive symptoms at the start of COVID-19 pandemic relative to before it.[1] Since the start of the COVID-19 pandemic, a number of studies have reported worsening mental health across a range of populations in the U.S.[2,3] and globally, including among healthcare workers,[4,5] children,[6] and the general public.[7,8] Depression is costly[9] and increases risk for other physical and mental illness,[10] as well as mortality.[10,11]

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Research in context

Evidence before this study

The COVID-19 pandemic has been associated with a three-fold increase in elevated depressive symptoms in U.S. adults. Unknown is whether depressive symptoms in the population level would increase, decrease, or stay the same over the course of the COVID-19 pandemic.

Added value of this study

This study follows a nationally representative group of participants over time, reporting on elevated depressive symptoms and symptom severity from March-April 2020 to March-April 2021. Using a longitudinal panel sample, this paper follows participants over the course of the COVID-19 pandemic and identifies risk factors for elevated depressive symptoms in U.S. adults.

Implications of all the available evidence

The impact of the COVID-19 pandemic on mental health has been ongoing and sustained at a population level. Depression disparities between persons of different income groups and stressor exposures are increasing. Additional attention and resources should be directed at groups that are at higher risk for depressive symptoms as the COVID-19 pandemic evolves.

Previous work has shown that stressors, such as job loss, and lower social and economic status, measured for example by low income or less wealth, are associated with greater risk of depressive symptoms, both in the context of the COVID-19 pandemic and before it.[12–15] During COVID-19, Holman et al. reported an increase in stressors over a one month period in Spring 2020 and corresponding increases in depressive symptoms during that period.[16] Also, populations with fewer economic resources have been shown to be more likely to experience COVID-19 stressors; in turn, persons who experienced COVID-19 stressors were more likely to report elevated depressive symptoms than persons who did not.[17]

Research following other traumatic events has shown that the mental health effects of stressful life events linger beyond the acute stressor.[18] While several cross-sectional studies[1,2,16] have shown a persistent high prevalence of elevated depressive symptoms in the U.S. over the past year, there is a paucity of studies that have followed a nationally representative sample over time to assess depressive symptom severity or the factors associated with depressive symptoms, during the course of the COVID-19 pandemic. Understanding the factors associated with depressive symptoms across time is important for determining how relations changed, if at all, and where future attention to prevent and mitigate the mental health burden of the COVID-19 pandemic should be directed.

This paper aimed to address this gap in the literature by documenting changes in depression severity, prevalence, and attendant risk factors over time during the pandemic using a nationally representative longitudinal cohort by 1) investigating how depressive symptoms formed during the start of the COVID-19 pandemic and evolved over the first year of the COVID-19 pandemic and 2) assessing how depressive symptom groupings (e.g., persistent, remitted, incident, and no elevated depressive symptoms) varied by COVID-19 induced stressor exposure over the course of the pandemic.

Methods

This study was conducted in compliance with the American Association for Public Opinion Research (AAPOR) reporting guidelines. The institutional review boards at NORC at the University of Chicago and Boston University approved this study. All participants provided written consent at both the enrolment process to join the AmeriSpeak standing panel and before starting each COVID-19 and Life Stressors Impact on Mental Health and Well-being (CLIMB) survey.

Population

Sample during the COVID-19 pandemic. The population surveyed was a nationally representative longitudinal sample of U.S. adults ages 18 years and older participating in the AmeriSpeak standing panel. Participants were invited to join the AmeriSpeak panel through a two-stage probability-based sampling design based on the 2010 U.S. Census that is representative of U.S. adults. AmeriSpeak members were recruited through mailings, telephone contacts, and in-person follow-up. Participants eligible for Wave 1 of the CLIMB study were a probability-based sample of the AmeriSpeak panel based on age, race/ethnicity, gender, and education who had responded to an AmeriSpeak survey within the last six months. The online and phone-based surveys were conducted at the beginning of the COVID-19 pandemic from March 31, 2020 - April 13, 2020 (Time 1, T1) and one year later with the same group from March 23, 2021 - April 19, 2021 (Time 2, T2) as part of the CLIMB panel study. Details on the AmeriSpeak sampling frame and on the CLIMB study can be found in previous writing.[1,17] Post-stratification weights were created; once applied, the survey weights aligned the study sample with the U.S. adult population based on the U.S. Current Population Survey.[19]

One thousand four hundred seventy participants completed the T1 survey (64.3% T1 completion rate). One thousand one hundred eighty-three participants completed the T2 survey for a T2 follow up rate of

81.1%. Twenty-nine and twenty-two participants were removed for incomplete depression data at T1 and T2, respectively. The cross-sectional analytic samples included 1441 participants at T1 and 1161 participants at T2. To get the most complete sample size possible, we included all participants at T1 for T1 cross-sectional analyses and all participants who responded at T2 for T2 cross-sectional analyses (including participants who responded to the depressive symptoms questions in the T2 survey but not in the T1 survey). The final longitudinal analytic sample included only participants who had answered questions at both T1 and T2. Responders at T2 and non-responders at T2 (n=287) were similar in gender and stressor exposure at T1. Non-responders at T2 were more likely to be younger (ages 18-39), be non-married, have lower income, and have reported depressive symptoms at T1 than responders. **Supplemental Table 1** shows the distribution of characteristics of T2 responders versus T2 non-responders.

Sample for comparison before the COVID-19 pandemic. We used data from the National Health and Nutrition Examination Survey (NHANES) collected in 2017-2018 to compare the prevalence of depressive symptoms before the COVID-19 pandemic. The NHANES is an ongoing study conducted by the U.S. government in two-year cycles, collecting information on mental health and demographic characteristics, among other variables. NHANES uses a four-part, probability-based sampling design including selection by county, census block, and household. Serving as a probability-based, nationally representative survey with geographic sampling design, the NHANES survey provides a comparison sample for population-level depressive symptoms in adults before the COVID-19 pandemic. The 5,065 participants in the NHANES sample used for this paper included adults ages 18 years and older and excluded participants who 1) were younger than 18 years of age (n=3398; 36.7%) and 2) had missing answers on depressive symptoms questions (n=791; 8.5%). The NHANES used the same measurements for depression —the Patient Health Questionnaire-9 (PHQ-9)—and demographic characteristics as used in the CLIMB surveys as described below. Additional details on the NHANES sample can be found in previous work.[1]

Key definitions

Depressive symptoms. Participants completed the Patient Health Questionnaire-9 (PHQ-9), which measures past two-week depressive symptoms, at T1 and T2. The two definitions used in this study for depressive symptoms included total depressive symptoms (continuous) and elevated depressive symptoms (binary). Total depressive symptoms were defined by participant scores on the PHQ-9, ranging from 0 to 27. Having elevated depressive symptoms was defined by a PHQ-9 score of 10 or greater. The PHQ-9 has been clinically validated and, using a score of 10 or greater, has a sensitivity of 88% and a specificity of 88% relative to the gold standard of clinical diagnosis of depression.[20] We also grouped elevated depressive symptoms into four categories across the two time points: elevated depressive symptoms at both times (persistent elevated depressive symptoms), elevated depressive symptoms at T1 but not T2 (remitted elevated depressive symptoms), elevated depressive symptoms at T2 but not T1 (incident elevated depressive symptoms), and no elevated depressive symptoms at T1 or T2 (no elevated depressive symptoms).

Stressors. Participants were asked if they had ever experienced a series of enumerated stressors due to COVID-19 at T1 and if they had experienced COVID-19 induced stressors in the past 12 months at T2. We measured 13 stressors, based on previous studies conducted after traumatic events[21] and as previously published.[1,17] Stressor counts were divided into three categories based on terciles at T2: low stressor count (0-1), medium stressor count (2-3), high stressor count (4 or more stressors).

Demographic characteristics and other key variables. Age was defined as a categorical variable: 18-39, 40-59, 60 years or older. Gender was defined as a binary variable: female or male. Race/ethnicity was defined as a mutually exclusive categorical variable: Non-Hispanic White, Non-Hispanic Black, Hispanic, Asian, and Other or multiple races. Education was defined as a categorical variable: less than high school degree, high school graduate or equivalent, vocational/technical school or some college, and bachelor's degree or more. Marital status was defined as a categorical variable: married; widowed, divorced or separated; never married; and living with partner. Household income was defined as a categorical variable: less than $20,000, $20,000-$44,999, $45,000-$74,999; and $75,000 or more. Family savings was defined as a binary variable: less than $5,000 or $5,000 or greater. Assets refer to family savings, home ownership, and income. Household size included all persons living in the home, ranging from 1 to 7 or more. COVID-19 diagnosis was defined in response to the question, "Has a doctor or other health professional ever told you that you had coronavirus or COVID-19?" measured at T1 and T2. Vaccination status was measured at T2; participants

were asked, "Have you received at least one shot of the COVID-19 vaccine?"

Analysis

First, we summarized the demographic characteristics of the longitudinal sample at T1 and T2. Second, we estimated the prevalence of elevated depressive symptoms at T1 and T2 by demographic characteristic, assets, and stressors at the corresponding time point; we also measured the cross-sectional associations of each characteristic, asset, and stressor with elevated depressive symptoms at the corresponding time point. Third, we estimated the distribution of continuous depressive symptom scores for T1, T2, and the NHANES comparison sample. Fourth, we estimated the unadjusted and adjusted odds ratios of elevated depressive symptoms across time using general estimating equations (GEE) to account for repeated measures for individuals over time using the CLIMB longitudinal sample. The adjusted model controlled for gender, age, race/ethnicity, education, marital status, household income, household savings, household size, and stressor category across time. Fifth, we estimated the adjusted odds for elevated depressive symptoms at T1 and T2, separately, in each time-specific sample. N=1,070 unique groups were measured at T1 and T2 in the fully adjusted GEE model. For these GEE analyses, we also adjusted for having been diagnosed with COVID-19 (T1 or T2) and vaccination status (T2 only) in sensitivity analyses. Sixth, we estimated the weighted prevalence of four groups of persons (incident, persistent, remitted, and no depression) by categories of low, medium, and high number of stressors. Supplemental analyses were conducted 1) to assess the association of relevant characteristics with changes in depressive symptom scores between T1 and T2, controlling for baseline depressive symptoms using linear regressions and 2) to assess the differences in each of the 9 separate items of the PHQ-9 between T1 and T2 using paired t-tests. All analyses used complex survey design weights that accounted for probability of selection into our sample, for sample retention through T2 using a raking ratio method, and to align our estimates with the demographic composition of the U.S. adult population. Analyses were conducted in Stata statistical software version 16.1 (StataCorp).

Role of funding source

The Rockefeller Foundation-Boston University 3-D Commission funded the CLIMB Time 1 survey. Members from the 3-D Commission (SG and SMA) contributed to drafts of the manuscript. The de Beaumont Foundation funded the CLIMB Time 2 survey. Members from the de Beaumont Foundation (BCC and RHB) provided feedback on the CLIMB questionnaire and provided edits to the manuscript.

Results

Among 1161 respondents in the sample for T2, 574 were women (51.8% weighted), 785 were non-Hispanic White (62.8% weighted), 588 were married (46.6% weighted), 384 earned more than $75,000 per year (30.9% weighted), 161 earned less than $20,000 per year (17.0% weighted), 362 had less than $5,000 in savings (35.1% weighted), and 433 persons (37.1% weighted) reported four or more COVID-19 stressors at T2.

Table 1 shows the frequency and weighted percentages of the sample populations with elevated depressive symptoms at T1 and T2. Among U.S. adults, 27.8% (95% CI: 24.9, 30.9) and 32.8% (95% CI: 29.1, 36.8) met criteria for elevated depressive symptoms at T1 and T2, respectively (p=0.0016). The difference in prevalence of elevated depressive symptoms was 5.7% with a 95% CI from 2.1% to 9.3%. Persons with the following characteristics had a higher weighted prevalence of elevated depressive symptoms at T2: younger age (43.9% of persons ages 18-39 years reported elevated depressive symptoms compared to 32.4% of persons ages 40-59 years and 19.1% of persons ages 60 years and older); lower income (58.1% of persons making $19,999 or less, 41.3% of persons making $20,000-$44,999, 31.4% of persons making $45,000-$74,999, and 14.1% of persons making $75,000 or more); having less than $5,000 in family savings (50.5% relative to 24.2% for persons with $5,000 or more in savings); and more self-reported stressors (51.1% of persons with 4 or more stressors, 25.8% of persons with 2-3 stressors, and 17.0% of persons with 0-1 stressors). All groups except persons making $75,000, persons with few stressors (0-1 COVID-19 stressors), and non-Hispanic Asian persons reported a higher prevalence of elevated depressive symptoms at T2 than T1.

Figure 1 shows the weighted prevalence of each depressive symptom score value before COVID-19, during COVID-19 in Spring 2020 (T1), and in Spring 2021 (T2). The weighted mean total PHQ-9 depressive symptom score increased from T1 to T2 when controlling for repeated responses by individuals (mean of 6.7 vs. 7.4, p<0.0001). Mean scores at both T1 and T2 were greater than the score reported before COVID-19 in 2017-2018 (mean of 3.16).

Table 2 shows the unadjusted and adjusted odds of elevated depressive symptoms at any given timepoint by demographic variables, assets, and stressors. Women had 1.6 times the odds of elevated depressive symptoms at any given timepoint relative to men (95% CI: 1.2, 2.2). Persons ages 18-39 years had 2.7 times the odds of elevated depressive symptoms at any given timepoint relative to persons ages 60 years or older (95% CI: 1.7, 4.3). Widowed, divorced, or separated persons had 1.7 times the odds (95% CI: 1.1, 2.6) and never married persons had 1.6 times the odds (95% CI: 1.1, 2.4) of elevated depressive symptoms at any given timepoint as married persons. Persons with $19,999 or less in

	2020 (T1)					2021 (T2)				
	Total		Elevated depressive symptoms			Total		Elevated depressive symptoms		
Characteristics	No.	%	No.	%	p-value	No.	%	No.	%	p-value
Total	1441		382	27.8		1161		341	32.8	
Gender					<0.0002					0.0989
Male	723	48.1	149	21.9		587	48.2	142	29.4	
Female	718	51.9	233	33.3		574	51.8	199	36.0	
Age, y					<0.0001					<0.0001
18-39	619	38.0	219	38.8		448	38.5	163	43.9	
40-59	462	32.4	113	26.8		379	31.5	117	32.4	
60+	360	29.7	50	14.9		334	30.0	61	19.1	
Race/ethnicity					0.3054					0.0796
Non-Hispanic White	933	62.9	225	26.5		785	62.8	224	33.0	
Non-Hispanic Black	143	11.9	36	24.2		96	11.9	22	24.7	
Hispanic	255	16.6	84	34.0		193	16.7	67	37.7	
Non-Hispanic Asian	36	3.1	8	23.1		29	3.1	4	12.4	
Other or multiple	74	5.6	29	34.4		58	5.5	24	44.8	
Education					<0.0001					0.0002
<High school	65	9.8	22	29.2		43	9.3	13	29.6	
High School graduate or equivalent	274	27.9	85	35.0		210	28.1	83	46.4	
Vocational/tech school/some college	637	27.8	186	32.0		516	27.8	165	34.2	
Bachelor's degree or more	465	34.5	89	18.3		392	34.9	80	21.7	
Marital status					<0.0001					<0.0001
Married	712	47.8	124	18.3		588	46.6	125	22.4	
Widowed, divorced, or separated	247	18.4	75	31.5		201	16.3	68	35.5	
Never married	344	24.2	130	39.8		265	27.6	103	45.4	
Living with partner	138	9.7	53	37.7		107	9.5	45	43.0	
Home ownership					<0.0001					<0.0001
Owned or being bought by you or someone you are related to	850	65.0	173	23.0		715	64.8	164	25.9	
Rented for cash	529	30.5	188	36.4		399	30.2	153	42.1	
Occupied without payment of cash rental	62	4.5	21	39.0		47	5.1	24	66.4	
Household income, $					<0.0001					<0.0001
≤19,999	246	19.8	116	46.9		161	17.0	83	58.1	
20,000-44,999	357	25.8	109	31.1		266	24.9	103	41.3	
45,000-74,999	357	25.1	83	23.3		311	27.3	93	31.4	
≥75,000	447	29.3	67	16.9		384	30.9	56	14.1	
Household savings, $					<0.0001					<0.0001
≤4,999	577	43.2	227	40.4		362	35.1	173	50.5	
≥5,000	819	56.8	146	19.3		750	64.9	161	24.2	
Stressor count category					<0.0001					<0.0001
Low (0-1)	236	14.8	36	19.5		293	26.4	47	17.0	
Medium (2-3)	525	37.7	95	18.0		435	36.5	101	25.8	
High (4 or more)	677	47.5	250	38.2		433	37.1	193	51.1	

***Table 1*: Associations of demographic characteristics, assets, and stressors with elevated depressive symptoms in 2020 and 2021.**
Note:
(a)Frequencies unweighted, percentages weighted. T1 weights used for T1 estimates; T2 weights used for T2 estimates.
(b)Elevated depressive symptoms defined by Patient Health Questionnaire−9 (PHQ-9) score of 10 or greater.
(c)Data source: COVID-19 and Life Stressors Impact on Mental Health and Well-being study. Time 1 collected from March 31, 2020, to April 13, 2020. Time 2 collected from March 24, 2021 to April 19, 2021.
(d)Covariates collected at Time 1 were used for Time 1 estimates; covariates collected at Time 2 were used for Time 2 estimates.

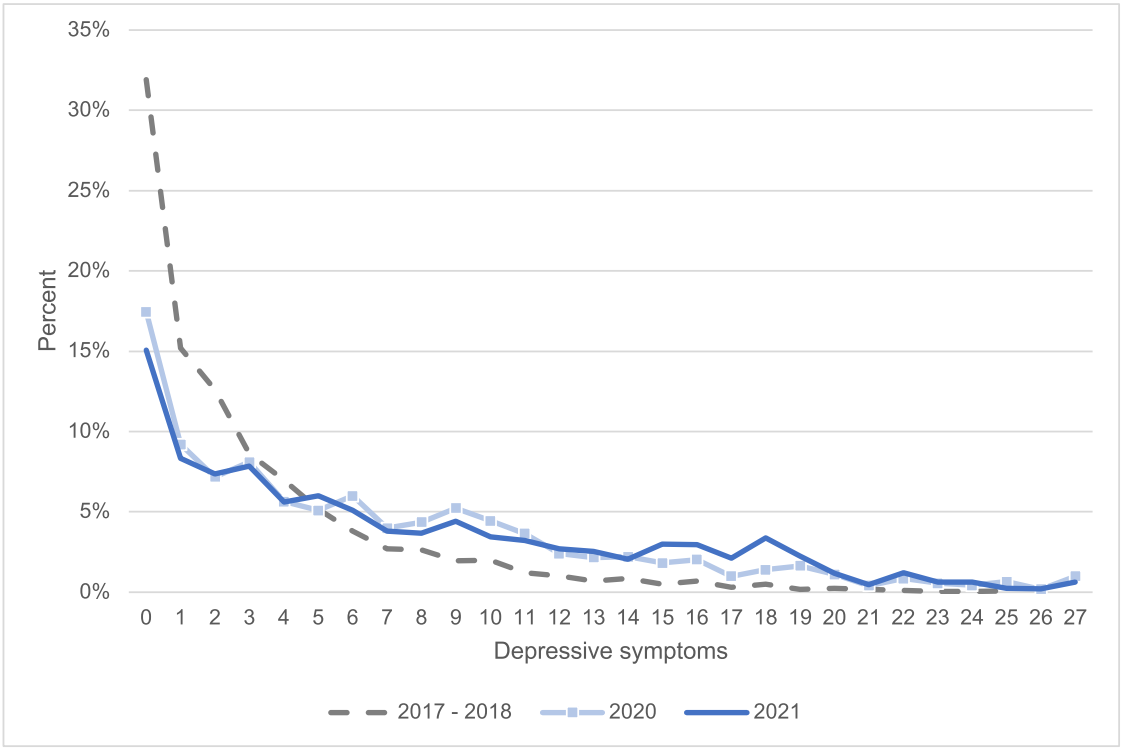

Figure 1. Distribution of depressive symptoms scores before the COVID-19 pandemic (2017-2018), at the start of COVID-19 (March-April 2020), and one year into the COVID-19 pandemic (March-April 2021).

Note: Depression symptoms measured using the Patient Health Questionnaire—9 (PHQ-9). Source: CLIMB: COVID19 and Life Stressors Impact on Mental Health and Well-being study. 2020 data: Time 1 collected from March 31, 2020, to April 13, 2020. 2021 data: Time 2 collected from March 24, 2021 to April 19, 2021. 2017-2018 data: National Health and Nutrition Examination Survey (NHANES). Relevant survey weights used to calculate percentages.

household income had 3.3 times the odds (95% CI: 2.0, 5.5), persons with $20,000 - $44,999 had 2.0 times the odds (95% CI: 1.3, 2.9), and persons making $45,000 - $74,999 had 1.4 times the odds (95% CI: 1.0, 2.0) of depression at any given timepoint relative to persons making $75,000 or more. Persons with less than $5,000 in family savings had 1.2 times the odds of elevated depressive symptoms (95% CI: 0.9, 1.7) relative to persons making $5,000 or more. Persons with high stressor count (4 or more COVID-19 stressors) had 2.1 times the odds of elevated depressive symptoms at any given timepoint relative to persons reporting low stressor count (0-1 stressors) (95% CI: 1.5, 2.9).

Table 3 shows the adjusted odds of elevated depressive symptoms at T1 and T2, respectively, across key assets and stressors. The likelihood of elevated depressive symptoms associated with having low-income and having more stressors increased from T1 to T2. At T1, having $19,999 or less in household income was associated with 2.3 times the odds of depression relative to incomes of $75,000 or more (95% CI: 1.2, 4.2); at T2, the association increased to 7.0 times the odds of elevated depressive symptoms for people with family incomes of $19,999 or less relative to persons with family incomes of $75,000 or more (95% CI: 3.7, 13.3). At T1, reporting 4 or more stressors was associated with 1.9 times the odds of elevated depressive symptoms (95% CI: 1.2, 3.1) whereas at T2, reporting 4 or more stressors was associated with 5.4 times the odds of elevated depressive symptoms (95% CI: 3.2, 9.2) when holding gender, age, race, education, marital status, household income, savings, and household size constant. There was no evidence of associations between marital status or household savings with elevated depressive symptoms at T2 when controlling for all other variables (unlike at T1). In secondary analyses (not shown), results were similar after further adjusting for COVID-19 diagnosis and vaccination status.

Figure 2 shows the weighted prevalence of elevated depressive symptoms status across time by exposure to stressors at T2; 58.4% of persons who experienced four or more COVID-19 stressors at T2 reported elevated depressive symptoms at T1, T2, or both. The likelihood of having no elevated depressive symptoms at T1 or T2 was greatest for persons reporting 0 or 1 stressors at T2; 78.5% of people with 0-1 stressors, 67.5% of people with

	Unadjusted				Adjusted model			
Characteristics	OR	95%CI		p-value	OR	95%CI		p-value
Gender								
Male	1 [Reference]				1 [Reference]			
Female	1.6	1.2	2.2	0.003	1.6	1.2	2.2	0.004
Age, y								
18-39	2.9	2.0	4.3	<0.0001	2.7	1.7	4.3	<0.0001
40-59	1.8	1.3	2.6	0.001	1.8	1.2	2.8	0.004
60+	1 [Reference]				1 [Reference]			
Race/ethnicity								
Non-Hispanic White	1 [Reference]				1 [Reference]			
Non-Hispanic Black	0.8	0.4	1.3	0.327	0.5	0.3	0.9	0.032
Hispanic	1.2	0.8	2.0	0.400	0.9	0.5	1.4	0.518
Non-Hispanic Asian	0.5	0.2	1.2	0.103	0.7	0.3	1.5	0.307
Other or multiple	1.4	0.7	2.6	0.305	0.9	0.5	1.7	0.819
Education								
<High school	2.0	0.9	4.4	0.103	1.0	0.4	2.2	0.923
High School graduate or equivalent	2.7	1.9	4.0	<0.0001	1.8	1.2	2.7	0.009
Vocational/tech school/some college	1.9	1.4	2.6	<0.0001	1.4	1.0	2.0	0.071
Bachelor's degree	1 [Reference]				1 [Reference]			
Marital status								
Married	1 [Reference]				1 [Reference]			
Widowed, divorced, or separated	2.0	1.4	3.0	<0.0001	1.7	1.1	2.6	0.021
Never married	2.7	1.9	4.0	<0.0001	1.6	1.1	2.4	0.018
Living with partner	3.0	1.7	5.3	<0.0001	1.6	0.9	2.7	0.117
Household income, $								
≤19,999	4.7	3.0	7.4	<0.0001	3.3	2.0	5.5	<0.0001
20,000-44,999	2.8	2.0	3.9	<0.0001	2.0	1.3	2.9	<0.0001
45,000-74,999	1.8	1.2	2.5	0.001	1.4	1.0	2.0	0.088
≥75,000	1 [Reference]				1 [Reference]			
Household savings, $								
≤4,999	2.1	1.5	3.0	<0.0001	1.2	0.9	1.7	0.248
≥5,000	1 [Reference]				1 [Reference]			
Stressor count category								
Low (0-1)	1 [Reference]				1 [Reference]			
Medium (2-3)	1.1	0.8	1.4	0.658	1.1	0.8	1.5	0.714
High (4 or more)	2.2	1.7	2.9	<0.0001	2.1	1.5	2.9	<0.0001
Household size	1.1	1.0	1.2	0.263	1.0	0.9	1.1	0.884

***Table 2*: Relation between demographic variables, assets, stressors and elevated depressive symptoms at any time during COVID-19.**

Note:

(a) Generalized estimating equation (GEE) used to account for repeated measurements of individuals over time. Unadjusted model presents bivariable relations. Adjusted model controlled for all variables in table.

(b) Data weighted using T2 weights.

(c) Elevated depressive symptoms defined by Patient Health Questionnaire−9 (PHQ-9) score of 10 or greater.

(d) Stressor count based on presence of: seeing family in person less, travel restrictions, death of someone close to you due to COVID-19, family or relationship problems, challenges finding childcare for your kids, feeling alone, not being able to get food due to shortages, not being able to get supplies due to shortages, losing a job, member of household losing a job, having financial problems, having difficulty paying rent, and being forced to leave campus.

(e) Data source: COVID-19 and Life Stressors Impact on Mental Health and Well-being study. Time 1 collected from March 31, 2020, to April 13, 2020. Time 2 collected from March 24, 2021 to April 19, 2021.

(f) N=1,070 unique groups measured at T1 and T2 in fully adjusted model.

(g) Assets defined as household income and household savings.

	Time 1: March - April 2020				Time 2: March - April 2021			
Characteristics	OR	95%CI		p-value	OR	95%CI		p-value
Education								
<High school	0.9	0.4	2.0	0.846	0.7	0.3	1.7	0.404
HS graduate or equivalent	1.6	1.0	2.7	0.051	1.8	1.1	3.0	0.024
Vocational/tech school/some college	1.5	1.0	2.2	0.050	1.3	0.8	1.9	0.259
Bachelor's degree	1 [Reference]				1 [Reference]			
Marital status								
Married	1 [Reference]				1 [Reference]			
Widowed, divorced, or separated	2.1	1.3	3.4	0.003	1.4	0.8	2.3	0.247
Never married	1.8	1.1	2.8	0.012	1.3	0.8	2.1	0.306
Living with partner	1.2	0.7	2.2	0.446	1.1	0.6	2.3	0.726
Household income, $								
≤19,999	2.3	1.2	4.2	0.009	7.0	3.7	13.3	<0.0001
20,000-44,999	1.3	0.8	2.3	0.276	3.3	1.9	5.7	<0.0001
45,000-74,999	1.0	0.6	1.7	0.883	1.8	1.1	3.0	0.021
≥75,000	1 [Reference]				1 [Reference]			
Household savings, $								
≤4999	1.5	1.0	2.3	0.035	1.4	0.9	2.2	0.111
≥5000	1 [Reference]				1 [Reference]			
Stressor count category								
Low (0-1)	1 [Reference]				1 [Reference]			
Medium (2-3)	0.8	0.5	1.4	0.515	2.0	1.2	3.5	0.010
High (4 or more)	1.9	1.2	3.1	0.011	5.4	3.2	9.2	<0.0001

***Table 3*: Adjusted associations among key assets, stressors, and elevated depressive symptoms at Time 1 (March-April 2020) and Time 2 (March-April 2021).**

Note:

(a) Models adjusted for gender, age, race/ethnicity, education, marital status, household income, household savings, stressors, and household size.

(b) Data weighted. Time 1 weights used for Time 1 analyses; Time 2 weights used for Time 2 analyses.

(c) Elevated depressive symptoms defined by Patient Health Questionnaire−9 (PHQ-9) score of 10 or greater.

(d) Stressor count based on presence of: Seeing family in person less, travel restrictions, death of someone close to you due to COVID-19, family or relationship problems, challenges finding childcare for your kids, feeling alone, not being able to get food due to shortages, not being able to get supplies due to shortages, losing a job, member of household losing a job, having financial problems, having difficulty paying rent, and being forced to leave campus.

(e) Data source: COVID-19 and Life Stressors Impact on Mental Health and Well-being study. Time 1 collected from March 31, 2020, to April 13, 2020. Time 2 collected from March 24, 2021 to April 19, 2021.

(f) Time 1, N=1386; Time 2, N= 1,105.

(g) Covariates collected at Time 1 were used for Time 1 estimates; covariates collected at Time 2 were used for Time 2 estimates.

2-3 stressors, and 41.6% of people with four or more COVID-19 stressors at T2 reported no elevated depressive symptoms at T1 or T2. More persons in the high stressor count group at T2 reported new elevated depressive symptoms at T2: 18.2% of persons in the high stressor count group, 9.2% of persons in the medium stressor count group, and 8.3% of persons in the low stressor count group reported presence of elevated depressive symptoms at T2 but not at T1. Persons with more COVID-19 stressors at T2 were more likely to have elevated depressive symptoms at both T1 and at T2 than persons with fewer T2 COVID-19 stressors: 32.4% of persons with high stressor counts, 16.7% of persons with medium stressor counts, and 8.2% of persons with low stressor counts reported elevated depressive symptoms at both T1 and T2.

Supplemental Table 2 shows that the following characteristics at T1 were associated with significant increases in depressive symptom scores between T1 and T2, controlling for baseline depressive symptoms: being ages 18-39 years, having never been married, having less than $75,000 in household income, having less than $5,000 in household savings, and reporting four or more COVID-19 stressors at T1. **Supplemental Table 3** shows that there was evidence of an increase at the p=0.05 level in the reporting of the following PHQ-9 symptoms between T1 and T2: trouble falling or staying asleep, or sleeping too much; feeling tired or having little energy; poor appetite or overeating; feeling bad about yourself or that you are a failure or have let yourself or others down; and thoughts that you would be better off dead, or thoughts of hurting yourself in some way.

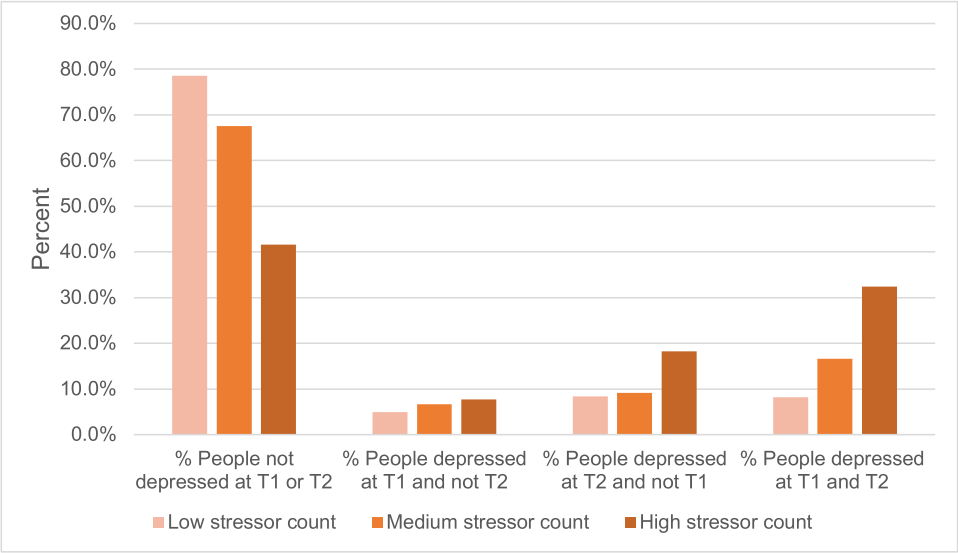

Figure 2. Prevalence of elevated depressive symptoms across time by exposure to COVID-19 related stressors in Spring 2021.

Note:

(a) T2 survey weights used to calculate percentages.

(b) Low stressor count (0-1), Medium stressor count (2-3), High stressor count (4 or more) defined by presence of: seeing family in person less, travel restrictions, death of someone close to you due to COVID-19, family or relationship problems, challenges finding childcare for your kids, feeling alone, not being able to get food due to shortages, not being able to get supplies due to shortages, losing a job, member of household losing a job, having financial problems, having difficulty paying rent, and being forced to leave campus.

(c) Elevated depressive symptoms defined by Patient Health Questionnaire−9 (PHQ-9) score of 10 or greater.

(d) Data source: COVID-19 and Life Stressors Impact on Mental Health and Well-being study. Time 1 collected from March 31, 2020, to April 13, 2020. Time 2 collected from March 24, 2021 to April 19, 2021.

Discussion

Using a nationally representative longitudinal panel study conducted during the COVID-19 pandemic, we found, first, that elevated depressive symptoms persisted in U.S. adults from 27.8% in March-April 2020 to 32.8% in March-April 2021. Second, we found that low household income, not being married, and experiencing four or more COVID-19 related stressors were consistently associated with depression over time. Third, being ages 18-39 years, experiencing more COVID-19 induced stressors, having never been married, having less than $5,000 in household savings, and having less than $75,000 in household income were significantly associated with increased depressive symptoms scores from Spring 2020 to Spring 2021. While we found that population level stressors decreased during the COVID-19 pandemic year, the association between higher stressor counts and elevated depressive symptoms grew stronger. Fourth, persons reporting more stressors over time were also least likely to have remitted outcomes. Thus, depressive symptom disparities between persons experiencing more and fewer stressors appear to be growing, with greater differences in 2021 than 2020. These differences may perpetuate or widen existing gaps between populations.[22]

Two types of literature may be helpful for contextualizing these findings: work that has measured mental health 1) over time in the context of the COVID-19 pandemic and 2) following other large-scale traumatic events (such as September 11th terrorist attacks, hurricanes, or other epidemics).

While, to the best of our knowledge, no previous longitudinal study has shown the sustained burden of depressive symptom severity during COVID-19 in a nationally representative sample of U.S. adults from 2020 through 2021, our findings are consistent with available estimates of the population burden of symptoms of depressive disorder during the pandemic. The Centers for Disease Control and Prevention (CDC) released an update on symptoms of depressive disorder during the past 7 days among adults ages 18 and over reporting symptoms of depressive disorder using a shortened form of the PHQ (a 4-item questionnaire that included 4 of the 9 items that we used). The CDC reported an increase in symptoms of depressive disorder from 24.5% to 30.2% from August 2020 to December 2020.[23] In a longitudinal study of the Understanding America cohort with Wave 1 conducted in March 2020 and Wave 2 conducted between April and August 2020, Riehm et al. found that participants below the poverty line were less likely to report high

resilience at Wave 2,[24] as measured by the Brief Resilience Scale, which measures constructs such as coping, sense of purpose, and social support.[25] They found that being male, being middle age and older, and adults with a graduate degree were more likely to report high psychological resilience, which is consistent with our findings of lower prevalence of depression at T2 among males, older persons, and persons with higher socioeconomic status. In a longitudinal cohort of U.S. adults surveyed in April and August 2020, McGinty et al. reported a prevalence of psychological distress of 13.7% in April 2020 and 13% in July 2020 using the Kessler 6 Psychological Distress Scale.[26] Consistent with our findings, they reported that disruptions to finances, education, or employment were associated with higher psychological distress. The association between lower socioeconomic status and worse mental health during COVID-19 has been reported in the U.S.[1,17,24,26] and in the U.K.,[27] Hong Kong,[15] and other countries.[28] The prevalence of elevated depressive symptoms we documented in this study is consistent with pooled estimates in reviews of studies on mental health during COVID-19. In a systematic review of 14 studies published through May 2020, Salari and colleagues estimated a global prevalence of depression of 33.7% among participants in China, Iran, Japan, Nepal, India, Iraq, Italy, the UK, Spain, and Nigeria.[7] Studies conducted in the UK noted an improvement in mental health over the first few months of the COVID-19 pandemic, but those studies concluded in August 2020[29] and October 2020,[30] and therefore may not capture mental health after one year of living with the COVID-19 pandemic. Also, conducted across seasons, these two studies may have been subject to seasonal effects, as acknowledged by the authors in their respective limitations sections.[29,30] Our study was conducted after 12 months of follow up in the same time period, thus controlling for potential bias of seasonal effects. Additionally, US residents had a different social, political, and economic experience than that of UK residents, including a contested presidential election over the course of 2020-2021, which may in part explain differences between mental health indicators in the U.S. and in other countries.

The persistence and magnitude of poor mental health at the start of the COVID-19 pandemic appear to be larger than estimates of the mental health burden of other large-scale traumatic events. For example, the prevalence of elevated depressive symptoms reported at the start of the COVID-19 pandemic (T1: 27.8%) was greater than the prevalence of elevated depressive symptoms reported within several months of other traumatic events such as Hurricane Ike (4.9%) (assessed using the PHQ-9);[31] Ebola in Sierra Leone (6%)(assessed using the PHQ-4);[32] and the Hong Kong Anti-extradition bill social unrest (11.2%)(assessed using the PHQ-9).[33] While these studies were conducted in different contexts across different populations, they provide context and framing for the levels of population-level elevated depressive symptoms measured following large-scale events.

In addition, the persistence of depression over one year contrasts with studies conducted after other large-scale traumatic events which generally show a decline in the prevalence of mental illness over a much shorter time frame. For example, following the September 11th attacks, Silver et al. documented a decrease in post-traumatic stress from 17% (2 months after the attacks) to 5.8% (6 months after the attacks).[34] In a longitudinal study of affected Texas residents, Gruebner et al. showed that 8.6% of participants still reported depression symptoms 8 months after Hurricane Ike (with 20.5% recovering from depression following the initial event and 10% reporting delayed onset).[35] The nature of COVID-19, including its duration and ubiquitous disruption may have contributed to the initial high prevalence of elevated depressive symptoms at the start of the COVID-19 pandemic and to the observed persistence over time.

Our findings need to be considered in light of three main limitations. First, loss to follow-up, a limitation in any longitudinal study, could bias estimates. Although we had a follow up rate of 81.1%, non-responders at T2 were more likely to be younger (ages 18-39), non-married, have lower income, and have reported elevated depressive symptoms at T1 than responders. This suggests that our findings may underestimate the full burden of depressive symptoms at the population level at T2. T2 survey weights accounted for non-response mitigating this concern. Second, depressive symptoms and stressors were measured concurrently, suggesting the possibility that persons with depressive symptoms were more likely to report stressors. However, participants reported on depressive symptoms in the past 2 weeks and on stressors experienced in the past 12 months. In addition, in sensitivity analyses, reporting 4 or more stressors at T1 was associated with incident depression (new depression at T2) further suggesting the hypothesized temporal relation between stressors and depression. Third, these data did not include information about whether participants were on antidepressants or were receiving psychotherapy; therefore, we are unable to comment on the dynamics between access to treatment and depressive symptoms over time. It is possible the risk factors identified in this study were present before the COVID-19 pandemic; our hope was to document the correlates with elevated depressive symptoms during the COVID-19 pandemic, given that different factors could explain changes in depressive symptoms or access to treatment before and during the COVID-19 pandemic. Previous research after the 2008 economic recession suggests that wealthy persons were more likely to be taking antidepressants following the economic downturn,[36] which could contribute additionally

to mental health gaps between persons with and without high income.

In summary, this study reports a high prevalence and continued persistence of elevated depressive symptoms among U.S. adults more than one year after the start of the COVID-19 pandemic, particularly among persons who had lower household income and experienced COVID-19 related stressors. As COVID-19 disruption declines and the U.S. begins a return to pre-pandemic behaviours, efforts should be invested in identifying persons who continue to experience stressors from COVID-19 and have fewer resources. Mental health interventions should be prioritized among this group. While much attention has rightly been paid to the physical health effects of the COVID-19 pandemic, this study suggests that depressive symptoms remain high at the population level and that socioeconomic inequities in mental health are widening.

Contributors

Conceptualization (CKE, PMV, SG), data curation (SG, CKE), formal analysis (CKE, GHC, LT), funding acquisition (CKE, SG, BCC, RHB, SMA), methodology (CKE, PMV, SG, LT, IW, MAC), supervision (SG, PMV), writing – original draft (CKE), and writing review & editing (CKE, GHC, SMA, LS, LT, BCC, RHB, MAC, IW, PMV, SG).

Declaration of Interests

The authors had no competing interests to declare. In the past three years, LS received support from the National Institutes of Health (R01 MH119193 and R01 MH107641), the U.S. Department of Justice (2017-MU-GX-K144), and the U.S. Department of Defense (W81XWH-15-1-0080).

Data sharing statement

Data are available upon reasonable request of the authors.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.lana.2021.100091.

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