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Extended impact of the COVID-19 pandemic: Trajectories of mental health and substance use among U.S. adults, September 2020–August 2021

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HIGHLIGHTS

- Adults' perceived impact of pandemic, stress, anxiety, alcohol use decreased but remained high.
- There was no change in depressive symptoms.
- Limited data constrained capturing curvilinear changes in substance use.
- Perceived impact of pandemic predicted changes in mental health risk.
- Self-report social status predicted baseline and changes in mental health risk.

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ABSTRACT

Background: Americans reported significant increases in mental health and substance use problems after the COVID-19 pandemic outbreak. This can be a product of the pandemic disruptions in everyday life, with some populations being more impacted than others.
Objectives: To assess the ongoing impact of the COVID-19 pandemic on mental health and substance use in U.S. adults from September 2020 to August 2021.
Methods: Participants included 1056 adults (68.5% women) who participated in a national longitudinal online survey assessing the perceived impact of COVID-19 on daily life, stress, depression and anxiety symptoms, and alcohol and cannabis use at 3-time points from September 2020 to August 2021.
Results: Individuals with lower self-reported social status reported the highest perceived impact. Participants' perceived impact of the COVID-19 pandemic on daily life, stress, anxiety, and alcohol use risk significantly decreased over time but remained high. However, there was no change in depressive symptoms and cannabis use. Higher levels of perceived impact of the pandemic significantly predicted both more baseline mental health concerns and lower decreases over time. Lower self-report social status predicted more baseline mental health concerns and smaller decreases in those concerns. Black adults reported significantly higher cannabis use rates than non-Hispanic White adults.
Conclusion: The impact of COVID-19 on daily life continued to be a risk factor for mental health during the second wave of the pandemic. In addition to infection prevention, public health policies should focus on pandemic-related social factors such as economic concerns and caretaking that continue to affect mental health.

A mental health crisis has accompanied the COVID-19 pandemic in the U.S. A substantial increase in mental health distress among U.S. adults was reported after the initial outbreak in March 2020 (Daly and Robinson, 2022; Holingue et al., 2020b, 2020a; Riehm et al., 2021; U.S. Census Bureau, 2020). However, subsequent longitudinal cohort studies indicated a return to baseline levels of psychological distress by June 2020 (Daly and Robinson, 2021; Robinson et al., 2022; U.S. Census Bureau, 2020). This trend was concurrent with mixed findings in

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substance use patterns, with some reports indicating that increased alcohol and cannabis use served as a coping strategy for pandemic-related distress during the outbreak (Chong et al., 2022; Rogers et al., 2020). Others reported a decrease due to pandemic-related policies and restrictions associated with the low accessibility of substances (Czeisler et al., 2020; Niles et al., 2021).

Research has suggested several key risk factors for psychological distress during the pandemic, including insufficient medical resources (Fisher et al., 2023), worries associated with COVID-19 infections (McKnight-Eily et al., 2021) or close contacts (Mazza et al., 2020), and social distancing policies associated with isolation and lack of social support (National Alliance on Mental Illness, 2021). The inconsistent findings observed across studies may be attributed to the impact of rapid changes in local and federal COVID-19 policies, the availability of vaccinations, and demographic variation in COVID-19 infection rates, reflecting the significance of examining individuals' perceptions of COVID-19 impact on daily life (Tull et al., 2020).

Despite the lack of consensus on the impact of the pandemic on mental health and substance use across time, research has consistently found disparities in the impact of the pandemic based on racial/ethnic and social status groups. Before the pandemic, Black, Indigenous, and People of Color (BIPOC), and individuals from disadvantaged socioeconomic backgrounds reported higher stress levels and had less access to healthcare resources (American Psychological Association, 2017). The COVID-19 pandemic has exacerbated such disparities, including significantly higher risks of contracting COVID-19 and related health and financial burdens (Fisher et al., 2023; Mazza et al., 2020; McKnight-Eily et al., 2021; Tao et al., 2022). For instance, as the U.S. began easing COVID-19 restrictions and vaccines became accessible in the second year of the pandemic, the number of COVID-19 positive cases per 100,000 population spiked in August 2021, particularly among Black (181.1) and American Indian/Alaska Native individuals (460.1), compared to Asian (68.2), Hispanic/Latino (145.3), and non-Hispanic White (147.3) people (CDC, 2021). Despite that 74.4% of U.S. adults have received at least one dose of vaccine by September 2021 (CDC, 2022)—and the reopening of schools for in-person instruction (Schiff, 2021), these pronounced disparities indicate a need for further exploration of mental health and substance use trajectories, particularly among vulnerable populations, during different stages of the pandemic. However, data on COVID-19-related mental health changes have been predominantly focused on the initial outbreak. To date, little is known about the extended mental health impact of COVID-19 during the second year of the pandemic, especially among vulnerable populations.

The current study utilized data from a longitudinal national survey in the U.S. collected from September 2020 to August 2021 that included baseline (Wave 1) and two subsequent time points to examine trajectories of the perceived impact of the pandemic on daily life and well-being. Further, we examined differences in those trajectories based on race/ethnicity and socioeconomic backgrounds. We hypothesized overall high levels of perceived impact of the pandemic and mental health concerns at Wave 1 followed by substantial decreases across time, with BIPOC individuals and those from disadvantaged socioeconomic backgrounds reporting higher Wave 1 stress, depression, and anxiety levels and less of a decrease over time. Given the inconsistency in data on pandemic-related substance use, the alcohol and cannabis use trajectories across time and the impact of the pandemic on substance use were assessed as exploratory analyses.

1. Methods

Participants were part of a large-scale longitudinal survey study on mental health during COVID-19. Eligible participants for the larger study were adults living in the U.S. with Facebook accounts, since the larger study focuses on the role of Facebook language usage in various aspects of participants' lives, including its impact on mental health. Participants were recruited through a Qualtrics Panel with monetary compensation for participation in each wave of the study (See Fig. 1). After removing low-quality data, including those with duplicate response IDs, poor completion rates, or failed all attention check questions, the Wave 1 survey ($n = 2505$) was done between September 30, 2020, to April 5, 2021 with participants entered on an ongoing basis. Data collection for Wave 2 ($n = 1430$, 57.1% of Wave 1 participants) included both a 30-day ecological momentary assessment (EMA) that began immediately after the Wave 1 data collection and a survey at approximately 60 days after Wave 1; Wave 3 occurred approximately 120 days after Wave 1, with 42.2% retention ($n = 1056$). Considering the rapid changes in COVID-19 public health protocols during 2020–2021, participants were classified into four cohorts based on the month they took the Wave 1 survey: September to October 2020 (28.0%); November to December 2020 (41.1%); January to February 2021 (19.3%); and March to April 2021 (11.6%). We then compared individuals who completed Wave 3 with those who dropped out based on age, gender, race/ethnicity, self-report social status, cohort entering Wave 1, political orientation, having had COVID-19, COVID-19 close contact, and caretaker status. Significant differences were observed only in race/ethnicity (χ^2 (1) = 10.0, $p = 0.04$), cohort (χ^2 (1) = 80.97, $p <$ 0.001), had COVID-19 (χ^2 (1) = 11.13, $p = <0.001$), and COVID-19 close contact (χ^2 (1) = 6.94, $p = 0.008$). Individuals identified as Black or non-Hispanic White participants, from the later cohort, who had COVID-19 or COVID-19 close contact were less likely to remain in the survey. The longitudinal survey study was approved by the [Anonymous] Institutional Review Board.

1.1. Measures

Demographic information was collected during the Wave 1 survey, including age, gender, self-reported race/ethnicity, political orientation, self-reported history of COVID-19 infection, whether any of the participants' close contacts had COVID-19, and whether they had been caretaking during the pandemic. COVID-19 vaccination status was collected at Wave 3. Response options for these variables are presented in Table 1.

1.1.1. Subjective social status

The MacArthur Scale of Subjective Social Status (Adler et al., 2000) was used in Wave 1, i.e., "This (ladder) represents where people stand in our society. At '10' are the people who are the best off, those who have the most money, most education, and best jobs. At '1' are the people who are the worst off, those who have the least money, least education, and worst jobs or no job. Move the slider to the point that best represents where you think you stand in society."

1.1.2. Impact of the pandemic on daily life

At each wave, a single item, "How much does/did COVID-19 (coronavirus) impact your day-to-day life?" was used to assess the impact of the pandemic on daily life, with response options ranging from 1 (Not at all) to 5 (Extremely). A second item asked, "During the past

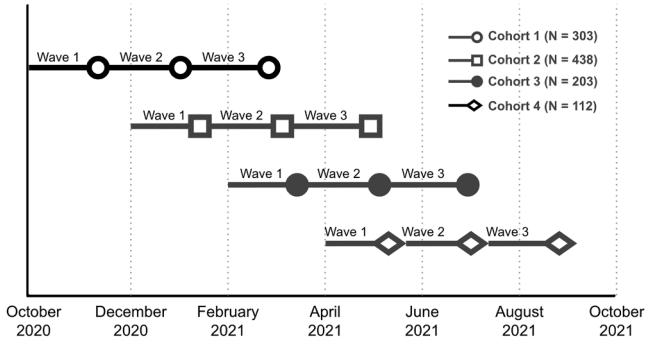

Fig. 1. Three-wave data collection timeline across four cohorts of participants. *Note.* Data collection started Sept 30th, 2020.

Table 1
Descriptive statistics of participants' characteristics, impact of pandemic, and mental health.

$n = 1056$	n	%
Cohort based on month joined the Wave 1 survey		
Sep. 30th–Oct. 31st 2020	303	28.7
Nov. 1st–Dec. 31st 2020	438	41.5
Jan. 1st–Feb. 29th 2020	203	19.2
Mar. 1st–Apr. 5th 2021	112	10.6
Gender (Wave 1)		
Women	723	68.5
Men	315	29.8
Self-describe	18	1.7
Race/Ethnicity (Wave 1)		
Asian	96	9.1
Black	132	12.5
Hispanic/Latino	103	9.8
Non-Hispanic White	701	66.4
Unlisted	24	2.3
Political orientation (Wave 1)		
Conservative	210	19.9
Moderate	168	15.9
Liberal	633	59.9
Apolitical/Other	45	4.3
Had COVID-19 (Wave 1)	182	17.2
COVID-19 close contact (Wave 1)	596	56.4
Caretaker (Wave 1)	142	13.4
At least one dose of COVID-19 vaccine (Wave 3)	892	84.5
Perceived impact of the pandemic on daily life (Wave 1)		
Not at all	20	1.9
A little	197	18.7
Much	273	25.9
Very much	335	31.8
Extremely	230	21.8
Thinking about COVID-19 infection risk affecting daily activities (Wave 1)		
Not at all	558	53.1
Sometimes	332	31.6
Often	104	9.9
A lot	56	5.3
Moderate to high stress at Wave 1 (Score >14)	676	64
Moderate depression risk at Wave 1 (Score >9)	346	32.8
Moderate anxiety level at Wave 1 (Score >5)	638	60.4
Alcohol use at Wave 1	825	78.1
Cannabis use at Wave 1	274	25.9
Variable	M (SD)	Range
Subjective social status	6.05 (1.71)	1–10

month, how often have thoughts about your chances (or risks) of getting COVID-19 affected your ability to perform daily activities?" with response options ranging from 1 (Not at all) to 4 (A lot).

1.1.3. Mental health

The following mental health measures were administered at each wave. Stress level in the past month was assessed using the Perceived Stress Scale (PSS; Cohen et al., 1997), which has been validated in the general population (Lee, 2012). A sample item is "In the last month, how often have you been upset because of something that happened unexpectedly?" Response options ranged from 0 (Never) to 4 (Very often). The frequency of depressive symptoms in the past month was assessed using the 9-item Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001). A sample item is "Trouble concentrating on things, such as reading the newspaper or watching television". Responses options ranged from 0 (Not at all) to 3 (Nearly every day). Prior research has shown the validity of the PHQ-9 scale across diverse U.S. populations (Huang et al., 2006). The frequency of anxiety symptoms in the past month was assessed using the General Anxiety Disorder Screener (GAD-7; Spitzer et al., 2006). A sample item is "Being so restless that it is hard to sit still". Response options ranged from 0 (Not at all) to 3 (Nearly every day). The scale's validity for diverse ethnic groups has been supported by prior research (Löwe et al., 2008). For all three scales, composite scale scores were computed by the sum of item responses.

1.1.4. Alcohol and cannabis use frequency

Wave 1 frequency of alcohol use was measured by the following item from the Alcohol Use Disorders Identification Test—Consumption (AUDIT-C; Bush et al., 1998): "How often do you have a drink containing alcohol? This includes beer, wine, and liquor." Response options ranged from 0 (Never) to 4 (Four or more times a week). Wave 2 alcohol use was measured by manually calculated frequency scores from the following daily EMA Yes/No question: "Did you drink yesterday?". At Wave 3, alcohol use was measured by one item from National Institute on Drug Abuse (NIDA)-modified Alcohol, Smoking and Substance Involvement Screening Test (ASSIST; NIDA, 2012) "In the past three months, have you used any of the following substances? - Alcohol (beer, wine, liquor, etc.)." Response options ranged from 0 (Never) to 6 (Daily or Almost Daily). We recoded the responses on Waves 2 and 3 to match the scoring of the AUDIT-C scale at Wave 1 (See Appendix A for details). At Wave 1 and Wave 3, cannabis use was assessed by the NIDA-ASSIST: "In the past 3 months, have you used any of the following substances? – Cannabis". For the EMA assessment, daily cannabis use was measured by a single question: "Did you use any drugs yesterday? - Cannabis." The participants were given a score of 1 if they indicated any of the listed drugs. We recoded the responses to the EMA assessment to match the response range of NIDA-ASSIST (See Appendix A).

1.2. Statistical analyses

Descriptive statistics for all studied variables are presented in Table 1. We calculated the bivariate associations among variables using analyses of variance (ANOVA) and correlation analyses. Bonferroni adjustment was used to determine the alpha value for the significance test for correlations ($\alpha = 0.05/16 = 0.003$). We then conducted latent growth curve models (LGCM), an analytic technique within the Structural Equation Modeling framework that permits inter- and intra-individual change tests over time. First, we identified two basic unconditional models (intercept-only model; intercept and slope model) for each variable to establish the growth shape. Likelihood ratio tests were used to compare the adoption of unconditional models. We then ran conditional models with race/ethnicity and socioeconomic backgrounds as predictors of intercepts and slopes or only intercepts. All demographic variables were included in conditional models as covariates, except for vaccination status, as it was found to be unrelated to any variables in our sample. Categorical demographics were dummy-coded. A final step added the impact of the pandemic factors as either time-variant or -invariant predictors in the conditional models to examine whether there were individual differences over time and determine which variables affect the rate of development.

All analyses were performed in R 3.6.1. LGCM models were conducted with '*lavaan*' package (Rosseel, 2012). We used a robust maximum likelihood estimator to account for missing data and correct for nonresponse for all models, except that for substance use models, diagonally weighted least squares estimator was adopted for more accurate estimates due to the rank nature of the responses (Li, 2021). In evaluating the goodness of fit of our model, we considered multiple fit indices, consistent with the guidelines of Hu and Bentler (1999). These included the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). While we aimed for CFI and TLI values greater than 0.90 and RMSEA values less than 0.06, we acknowledged that these are guidelines rather than strict cut-offs. Considering the complexity of our models, we interpreted the model as having an acceptable fit when the majority of these indices met the recommended values.

2. Results

A summary of sample characteristics and the perceived impact of COVID-19 and mental health is provided in Table 1. Participants aged 18–74 ($M = 38.85$, SD = 18.67). The majority (68.5%) are women

(29.8% men). The sample primarily consisted of non-Hispanic White individuals (66.4%), with 9.1% identifying as Asian, 12.5% as Black, 9.8% as Hispanic/Latino, and 2.3% falling under the unlisted category. Most (84.5%) participants were vaccinated with at least one dose by Wave 3. The average score of subjective social status is 6.0 (SD = 1.7, *Range* = 1–10). For political orientation, 59.9% indicated they were "moderately" to "very" liberal. Around 17.2% of participants reported had COVID-19, and 56.4% had at least one close contact infected with COVID-19.

2.1. Perceived impact of the pandemic

2.1.1. Wave 1 impact of pandemic on daily life and daily activities

In Wave 1, participants reported high levels of pandemic impact on daily life ($M = 3.53$, $SD = 1.08$, *Range* = 1–5). Most participants (79.5%) indicated the pandemic "much" to "extremely" impacted their daily life. About half (46.9%) indicated that thinking about the risks of getting COVID-19 affected their ability to perform daily activities. The higher perceived impact was significantly correlated with younger age, lower subjective social status, liberal political orientation, and had COVID-19 or close contact with COVID-19 (See Table 2). Cohort, caretaking, or vaccination status were unrelated to the perceived impact of the pandemic. Contrary to our hypothesis, no racial/ethnic differences emerged in Wave 1 perceived impact of pandemic (see Table 3).

2.1.2. The trajectory of pandemic impact on daily life

The intercept-only model had an acceptable fit (CFI = 0.97, TLI = 0.98, RMSEA = 0.09; see Table 4 for *M*s, *SD*s, and parameter estimates). The intercept and slope model had a significantly better fit, CFI = 1.0, TLI = 0.99 RMSEA = 0.02, $\Delta x^2(1,4) = 38.10$, $p < 0.001$, slope $M = -0.09$, $p < 0.001$, suggesting a significant decrease in the perceived impact over time across people. After adding demographics into the model, CFI = 1.0, TLI = 0.99, RMSEA = 0.01, lower self-reported social status significantly predicted a higher perceived impact of the pandemic at Wave 1 ($b = -0.11$, $p = 0.004$) and a lower decrease over time ($b = 0.26$, $p < 0.001$). Other demographic differences as in the bivariate analysis were observed.

2.1.3. The trajectory of the pandemic impact on daily activities

The intercept-only model (CFI = 0.98, TLI = 0.99, RMSEA = 0.06) had a similar fit as the intercept and the slope model, (CFI = 0.99, TLI = 0.96, RMSEA = 0.10), $\Delta x^2(1,4) = 5.24$, $p = 0.15$. The slope mean was not statistically different from zero (see Table 4), indicating no within-individual change in daily activities across waves. After adding demographics into the model, CFI = 0.97, TLI = 0.96, RMSEA = 0.02, lower self-reported social status significantly predicted a higher perceived impact of the pandemic at Wave 1 ($b = -0.16$, $p < 0.001$). Asian ($b = 0.08$, $p = 0.02$) participants reported significantly more impact on daily activities than non-Hispanic White participants. Wave 1 score differences also emerged based on age, cohort, political orientation, COVID-19 close contacts, and caretaker status.

2.2. Mental health

2.2.1. Wave 1 mental health

In Wave 1, 64% of participants perceived moderate to high levels of stress (score >14), 32.8% were at risk for depression (score >9), 60.4% reported moderate to high anxiety levels (score >5), 78.1% used alcohol, and 25.9% used cannabis (See Table 1). Results of the ANOVA indicate racial/ethnic differences only in cannabis use in Wave 1, with Black adults reported significantly more cannabis use than non-Hispanic White adults (See Table 3). Bivariate analyses on Wave 1 data (See Table 2) yielded significant positive associations between mental health indices and younger age, women, liberal political orientation, earlier cohort, caretaking responsibilities, having close contacts with COVID-19, and lower subjective social status.

2.2.2. The trajectory of perceived stress

For stress responses collected at each of the three waves, the model fit estimating intercept only was acceptable (CFI = 0.97, TLI = 0.98, RMSEA = 0.10; see Table 5 for *M*s, *SD*s, and parameter estimates). The intercept and slope model had a significantly better fit, CFI = 1.0, TLI = 1.0, RMSEA = 0.00, $\Delta x^2(1,4) = 45.10$, $p < 0.001$, slope $M = -0.54$, $p < 0.001$, indicating decreases in stress over time. After adding demographics into the model, CFI = 1.0, TLI = 1.0, RMSEA = 0.00, lower subjective social status significantly predicted higher perceived stress at Wave 1 ($b = -0.31$, $p < 0.001$), and a lower decrease in stress ($b = 0.20$, $p = 0.001$). After adding pandemic-related predictors into the model (CFI = 0.98, TLI = 0.97, RMSEA = 0.04), perceived impact on daily activities significantly predicted both intercept ($b = 0.32$, $p < 0.001$) and slope ($b = -0.18$, $p = 0.02$). Individuals with higher perceived impact of COVID-19 risk on daily activities had higher perceived stress at Wave 1 and lower decrease over time. At each wave, a higher perceived impact of the pandemic on daily life scores was significantly associated with greater perceived stress (*bs* = 0.16–0.18, *ps* < 0.001).

2.2.3. The trajectory of depressive symptoms

The model fit estimating an intercept-only model was good (CFI = 1.0, TLI = 1.0, RMSEA = 0.04; see Table 5). The intercept and slope model had a significantly better fit, CFI = 1.0, TLI = 1.0, RMSEA = 0.00,

Table 2
Correlation table for studied variables and demographics at wave 1.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Impact of Pandemic on daily life	1	**0.3**	**0.34**	**0.23**	**0.34**	**0.14**	0.06	**−0.1**	0.08	−0.1	**0.14**	**0.09**	**0.09**	−0.07	0.06	0
2. Impact of COVID-19 risk on daily activities		1	**0.35**	**0.34**	**0.42**	0.08	−0.02	**−0.14**	−0.02	**−0.12**	0.07	0	0.06	−0.04	0.06	0.01
3. Perceived stress			1	**0.68**	**0.74**	−0.01	0.06	**−0.19**	**0.16**	**−0.29**	**0.13**	0.04	0.07	**−0.1**	0.08	0.03
4. Depressive symptoms				1	**0.79**	−0.06	0.06	**−0.21**	**0.15**	**−0.35**	**0.14**	0.05	0.07	**−0.1**	0.07	0.03
5. Anxiety symptoms					1	−0.01	0.06	**−0.23**	**0.18**	**−0.31**	**0.16**	0.02	0.1	**−0.12**	**0.11**	0.02
6. Alcohol use frequency						1	0.2	0	−0.08	**0.11**	0.05	0.02	**0.11**	−0.01	−0.04	−0.04
7. Cannabis use frequency							1	−0.11	0.05	−0.07	**0.09**	0.01	0.08	−0.01	0.03	0.02
8. Age								1	−0.14	0.04	−0.2	−0.06	−0.05	0.05	−0.04	−0.06
9. Gender									1	**−0.09**	**0.14**	−0.01	0.08	**−0.15**	0.08	0.01
10. Subjective social status										1	**−0.09**	−0.01	−0.01	**0.1**	−0.03	0
11. Political orientation											1	−0.04	−0.01	−0.03	0.04	−0.02
12. Having had COVID-19												1	**0.21**	0.04	0.06	−0.02
13. Close contacts with COVID-19													1	0.01	0.08	−0.02
14. Cohort														1	−0.01	0.05
15. Caretaking															1	−0.06
16. Vaccination status																1

Note. Significant results ($p < 0.003$) are in bold.

Table 3
Means, standard deviations, and ANOVA test results for perceived impact of pandemic factors and mental health across race/ethnicity.

	Asian	Black	Hispanic/Latino	Non-Hispanic White	Unlisted	ANOVA test results
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	
n	96	132	103	701	24	
Impact of pandemic on daily life	3.56 (1.07)	3.57 (1.09)	3.65 (1.18)	3.50 (1.07)	3.54 (1.02)	$F(4) = 0.53$, $p = 0.72$
Impact of COVID-19 risk on daily activities	1.80 (0.83)	1.67 (0.83)	1.82 (0.96)	1.64 (0.86)	1.46 (0.72)	$F(4) = 1.84$, $p = 0.12$
Perceived stress	16.64 (6.19)	17.07 (7.14)	17.90 (7.56)	16.18 (6.31)	16.42 (5.69)	$F(4) = 1.88$, $p = 0.11$
Depressive symptoms	6.73 (6.21)	6.99 (5.87)	8.20 (7.11)	6.72 (5.89)	8.29 (5.17)	$F(4) = 1.70$, $p = 0.15$
Anxiety symptoms	6.85 (5.74)	7.23 (5.55)	7.55 (6.52)	6.81 (5.47)	7.83 (4.47)	$F(4) = 0.65$, $p = 0.63$
Alcohol use frequency	2.34 (1.74)	2.55 (1.50)	2.62 (1.79)	2.67 (1.83)	2.00 (1.50)	$F(4) = 1.49$, $p = 0.20$
Cannabis use frequency	2.03 (1.80)	2.28 (2.24)	2.01 (1.59)	1.97 (1.47)	2.40 (1.82)	$F(4) = 2.51$, $p = 0.04$

$\Delta x^2(1,4) = 10.44$, $p = 0.02$, however, the slope was non-significant ($b = 0.03$, $p = 0.64$), thus we adopted the intercept-only model in the follow-up analysis. After adding demographics into the model, CFI = 0.98, TLI = 0.98, RMSEA = 0.03, individuals with lower subjective social status ($b = -0.32$, $p < 0.001$) significantly predicted higher Wave 1 depressive symptoms. After adding pandemic-related predictors into the model (CFI = 0.98, TLI = 0.98, RMSEA = 0.03), higher perceived impact on daily activities significantly predicted Wave 1 depressive symptoms ($b = 0.26$, $p < 0.001$). At each wave, a higher perceived impact of the pandemic on daily life scores was significantly associated with more depressive symptoms ($bs = 0.10$–0.12, $ps < 0.001$).

2.2.4. The trajectory of anxiety symptoms

The model fit estimating intercept only was acceptable (CFI = 0.99, TLI = 0.98, RMSEA = 0.11; see Table 5). The intercept and slope model had a significantly better fit, CFI = 1.0, TLI = 1.0, RMSEA = 0.00, $\Delta x^2(1,4) = 50.73$, $p < 0.001$, slope $M = -0.36$, $\sigma^2 = 1.92$, $ps < 0.001$, indicating different decreases in anxiety over time across individuals. A significant association was found between intercept and slope ($b = -0.35$, $p < 0.001$), indicating that those with greater Wave 1 anxiety had lower decreases over time. After adding demographics into the model, CFI = 1.0, TLI = 1.0, RMSEA = 0.00, lower social status predicted higher Wave 1 anxiety levels ($b = -0.29$, $p < 0.001$) and a lower decrease ($b = 0.15$, $p = 0.004$). After adding pandemic-related predictors into the model (CFI = 0.99, TLI = 0.98, RMSEA = 0.03), perceived impact on daily activities significantly predicted intercept ($b = 0.36$, $p < 0.001$) and slope ($b = -0.16$, $p = 0.005$). Individuals with scores indicating a higher perceived impact of COVID-19 risk on daily activities score had higher anxiety levels at Wave 1 and lower decrease over time. Higher perceived impact on daily life was significantly associated with higher anxiety levels in each wave ($bs = 0.14$–0.16, $ps < 0.001$).

2.2.5. The trajectory of alcohol use

The model fit estimating intercept for alcohol use was acceptable (CFI = 0.99, TLI = 0.99, RMSEA = 0.07; See Table 5). The intercept and slope model had a significantly better fit, CFI = 0.99, TLI = 0.98, RMSEA = 0.11, $\Delta x^2(1,4) = 43.36$, $p < 0.001$, slope $M = -0.08$, $p < 0.001$, indicating decreases in alcohol use over time. After adding demographics into the model, CFI = 0.99, TLI = 0.97, RMSEA = 0.03, higher subjective social status significantly predicted higher alcohol use at Wave 1 ($b = 0.12$, $p < 0.001$). After adding pandemic-related predictors, CFI = 0.99, TLI = 0.97, RMSEA = 0.03, a higher perceived impact of the pandemic on daily life and daily activities were both only significantly associated with more alcohol use ($bs = 0.06$ & 0.07, $p = 0.03$ & <0.001). However, the limited number of time points (three) in the study may restrict the ability to estimate a curvilinear form of change in alcohol use.

2.2.6. The trajectory of cannabis use

The model fit estimating intercept for cannabis use was acceptable (CFI = 0.98, TLI = 0.99, RMSEA = 0.05; See Table 5). The intercept and slope model had a similar fit, CFI = 0.98, TLI = 0.94, RMSEA = 0.10, $\Delta x^2(1,4) = 6.70$, $p = 0.08$, suggesting no changes in cannabis use. However, the three-time points in the study may restrict the ability to estimate a curvilinear form of change in cannabis use. After adding demographics into the intercept-only model, CFI = 0.97, TLI = 0.96, RMSEA = 0.04, individuals with lower subjective social status ($b = -0.07$, $p = 0.004$) significantly predicted higher Wave cannabis use. Black participants reported significantly more cannabis use than non-Hispanic White participants ($b = 0.10$, $p = 0.01$). After adding pandemic-related predictors into the model (CFI = 0.99, TLI = 0.99, RMSEA = 0.02), lower perceived impact on daily activities significantly predicted Wave 1 cannabis use ($b = -0.07$, $p = 0.03$). Perceived impact of the pandemic on daily life scores was unrelated to cannabis use.

3. Discussion

This study is the first large-scale survey to capture trajectories of mental health and substance use during the second year of the COVID-19 pandemic in the U.S. Previous literature has yielded inconsistent findings examining mental health and substance use patterns following the initial outbreak of the pandemic that may be explained by rapid changes in COVID-19 policies and vaccination availability (Chong et al., 2022; Daly and Robinson, 2021; Robinson et al., 2022; Rogers et al., 2020; U.S. Census Bureau, 2020). Through the analysis of a diverse sample over an extended time frame, our data provide valuable insights into the enduring nature of challenges faced by individuals during the COVID-19 pandemic, even after the majority had received vaccinations and social distancing policies had been lifted. Participants reported high levels of perceived impact of the COVID-19 pandemic on daily life, stress, and anxiety that significantly decreased over time, while the high rates of depressive symptoms did not change. Demographic characteristics such as age and gender were associated with the perceived impact of the pandemic. Having had COVID-19 was associated with higher levels of perceived impact of the pandemic at Wave 1. Consistent with our hypotheses, individuals with lower self-reported social status reported the highest perceived impact. Although the perceived impact of the pandemic decreased over time, those with lower social status had significantly lower decreases than others. This may be explained by their pre-existing health and financial disparities and associated high risk of COVID-19 infections (Fisher et al., 2023; Mazza et al., 2020; McKnight-Eily et al., 2021; Tao et al., 2022). Individuals with lower social status were also more likely to work outside the home, significantly increasing their COVID-19 infection risk (Fisher et al., 2023).

The impact of COVID-19 on daily life was significantly associated with mental health over time, indicating an ongoing mental health crisis due to the pandemic. In accordance with recent research, demographic factors such as age, gender, and caretaking were associated with mental health (Hoyt et al., 2021; Mazza et al., 2020). Having had COVID-19 was unrelated to distress, yet having close contact with COVID-19 was. This suggests that the mental health impact of caretaking for COVID-19-vulnerable friends and family members may be a greater mental health risk than one's infection status. Unlike a personal infection, caretaking often involves sustained, high-stress engagement over a long period associated with a high risk of mental health disorders, e.g., depression (Adelman et al., 2014; Schulz and Sherwood, 2008). The

Table 4
Means, standard deviations and parameter estimates for perceived impact of pandemic factors.

	Impact of pandemic on daily life	Impact of COVID-19 risk on daily activities[a]
1. Descriptives	M(SD)	M(SD)
Wave 1	3.53 (1.08)	1.67 (0.86)
Wave 2	3.47 (1.11)	1.59 (0.84)
Wave 3	3.35 (1.15)	1.64 (0.84)
2. Intercept-only model		
M (σ2)	**3.46 (0.8)**	**1.63 (0.37)**
3. Intercept and slope model		
Mint (σ2)	**3.54 (0.8)**	**1.65 (0.41)**
Mslp (σ2)	**−0.09 (0.03)**	−0.02 (0.04)
Covariance	−0.09	−0.28
4. Covariate model		
Intercept		
Age	−0.07 (−0.01)	**−0.14 (−0.01)**
Gender (ref: Men)		
Women	0.05 (0.10)	−0.03 (−0.07)
Self-describe	0.05 (0.38)	0.01 (0.05)
Race/ethnicity (ref: non-Hispanic White)		
Asian	0.02 (0.07)	**0.08 (0.29)**
Black	−0.01 (−0.03)	0.01 (0.04)
Hispanic/Latino	0.01 (0.05)	**0.08 (0.25)**
Unlisted	−0.01 (−0.07)	−0.02 (−0.12)
Self-reported social status	**−0.11 (−0.06)**	**−0.16 (−0.09)**
Political orientation (ref: Conservative)		
Moderate	**0.12 (0.34)**	**0.11 (0.29)**
Liberal	**0.23 (0.45)**	**0.11 (0.22)**
Apolitical/Other	0.01 (0.06)	0.02 (0.08)
Cohort (ref: Sep. 1st–Oct. 31th 2020)		
Nov. 1st–Dec. 31th 2020	0.002 (−0.004)	**−0.08 (−0.17)**
Jan. 1st–Feb. 29th 2020	−0.03 (−0.07)	**−0.12 (−0.30)**
Mar. 1st–Apr. 5th 2021	−0.06 (−0.18)	−0.07 (−0.22)
Had COVID-19	**0.09(0.24)**	−0.04 (−0.09)
Had close contacts with COVID-19	**0.09 (0.18)**	**0.10 (0.19)**
Caretaker	0.04 (0.10)	**0.12 (0.35)**
Slope		
Age	0.03 (0.002)	
Gender (ref: Men)		
Women	0.03 (0.07)	
Self-describe	0.08 (0.64)	
Race/ethnicity (ref: Non-Hispanic White)		
Asian	0.06 (0.20)	
Black	0.04 (0.13)	
Hispanic/Latino	0.07 (0.23)	
Unlisted	0.05 (0.34)	
Self-reported social status	**0.26 (0.15)**	
Political orientation (ref: Conservative)		
Moderate	0.01 (0.02)	
Liberal	−0.05 (−0.11)	
Apolitical/Other	0.10 (0.49)	
Cohort (ref: Sep. 1st–Oct. 31th 2020)		
Nov. 1st–Dec. 31th 2020	**−0.16 (−0.33)**	
Jan. 1st–Feb. 29th 2020	**−0.46 (−1.17)**	
Mar. 1st–Apr. 5th 2021	**−0.21 (−0.68)**	
Having had COVID-19	−0.09 (−0.25)	
Having had close contacts with COVID-19	0.05 (0.09)	
Caretaker	0.04 (0.11)	

Note. The Means and Variances are unstandardized, and all other estimates are standardized results. Statistically significant results are in bold ($p < 0.05$).
[a] The covariate model is based on the intercept-only model.

constant worry for a loved one's well-being, coupled with the physical demands and the potential fear of getting infected, may intensify distress. Consistent with our findings, Czeisler et al. (2021) also found that in June 2020, caregivers in the U.S. had higher adverse mental health symptom prevalence than non-caregivers, including depressive and anxiety symptoms, as well as started or increased substance use to cope with the pandemic. Our results underscore the importance of public health policies that support caregivers, especially during pandemics, including mental health resources and services targeted towards caregivers, workplace flexibility for those balancing employment with caregiving responsibilities, and increased support for respite care services that give caregivers temporary relief.

Social status was related to all mental health concerns across time. Although stress and anxiety significantly decreased, those with lower subjective social status and higher perceived impact of the pandemic had a significantly smaller decrease than others. This highlights the mental health disparities experienced by the vulnerable populations who have already been disproportionally impacted by the pandemic. Lower-income populations, who often face higher rates of unemployment, inadequate housing, and limited access to health care, are particularly susceptible to increased stress and anxiety in pandemic situations, with research supporting that financial burdens were associated with increased depressive and anxiety symptoms and substance use during the initial outbreak of the pandemic (Lechner et al., 2021; Fisher et al., 2023; Tao et al., 2022).

COVID-19 vaccination status at Wave 3 was unrelated to any studied variables, possibly due to the high vaccination rate in U.S. adults during the later period of the pandemic (CDC, 2022). While vaccinations are crucial for controlling the spread of the virus and reducing physical health risks, our findings suggest they may not directly mitigate the mental health impacts of the pandemic. This underscores the need for complementary public health strategies beyond vaccination, such as widespread mental health screening and accessible support services, to address the persistent psychological repercussions of the pandemic.

Gender disparities in mental health emerged. Women reported more stress, depressive and anxiety symptoms, and similar levels of cannabis use compared to men. The pandemic has exacerbated pre-existing social and economic inequities, with women often bearing the brunt of these impacts (Smith et al., 2021). Women tend to shoulder a larger share of caregiving responsibilities, which may have been particularly stressful during the pandemic due to the heightened health risks and increased care needs (Hoyt et al., 2021). The economic disruptions caused by the pandemic have disproportionately affected industries with high female employment, potentially contributing to increased financial stress and mental health issues among women (Alon et al., 2020). Future studies should continue to examine these structurally imposed strains on women that may help explain women's mental health disparities during the pandemic. It's crucial to better understand these dynamics to inform policy measures and interventions that adequately support women's mental health during public health crises.

The longitudinal data in our study collected throughout the second year of the COVID-19 outbreak suggests the mental health crisis in the U.S. beyond the initial onset of the pandemic. However, we recognize a few limitations in our study. One limitation is the relatively short follow-up period of only 4 months, which has restricted our ability to capture long-term changes in mental health outcomes. The lack of change in cannabis use in our study may be due to variations in the measures of substance use across different waves, the potential presence of nonlinear trajectories, and the limited variability in substance use across time, as this sample reported a low risk of cannabis use across three waves. For instance, despite significant differences between Black and non-Hispanic White participants, both mean values of 0.9 and 1.3 represent individuals who reported cannabis use as 'less than once or twice' in the past month. Moreover, data in our study only include adults with Facebook accounts, which limits the generalizability of our results to populations with access to Facebook. The demographics of Facebook users may not reflect the broader population. According to a national survey by the Pew Research Center (Auxier and Anderson, 2021), 69% of adults used Facebook in 2021, with notable representation across various age groups and socio-economic statuses. While the platform is popular across diverse age groups, it is important to consider that a significant proportion of adults, particularly those from lower socio-economic statuses, may lack consistent internet access and thus are underrepresented. Moreover, 57.1% of participants who completed Wave 1 retained until Wave 3 with individuals identified as Black or

Table 5
Means, standard deviations and parameter estimates for mental health.

	Perceived stress	Depressive symptoms	Anxiety symptoms	Alcohol use	Cannabis use
1. Descriptives	*M(SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Wave 1	16.50 (6.54)	6.94 (6.04)	6.96 (5.59)	2.61 (1.78)	1.62 (2.04)
Wave 2	16.00 (6.17)	6.89 (6.04)	6.65 (5.57)	2.26 (2.01)	0.71 (1.70)
Wave 3	15.40 (6.35)	7.00 (6.18)	6.24 (5.49)	2.79 (1.82)	1.63 (2.08)
2. Intercept-only model					
M (σ^2)	**15.96 (26.64)**	**6.92(29.91)**	**6.63 (24.06)**	**2.46 (2.87)**	**0.85 (2.46)**
3. Intercept and slope model					
M_{int} (σ^2)	**16.50 (29.45)**	**6.91(32.03)**	**6.97 (27.56)**	**2.53 (2.65)**	0.83 (0.05)
M_{slp} (σ^2)	**−0.54** (1.14)	0.03(2.11)	**−0.36 (1.92)**	**−0.08 (0.07)**	0.02 (−0.04)
Covariance	−0.30	−0.24	**−0.35**	0.19	0.33
4. Covariate model					
Intercept					
Age	**−0.17 (−0.01)**	**−0.17 (−0.01)**	**−0.20 (−0.02)**	−0.02 (−0.001)	**−0.07 (−0.01)**
Gender (ref: Men)					
Women	**0.09 (0.20)**	**0.08 (0.17)**	**0.08 (0.16)**	**−0.08 (−0.17)**	0.01 (0.02)
Self-describe	0.05 (0.40)	0.04 (0.33)	**0.07 (0.53)**	**−0.06 (−0.46)**	0.05 (0.39)
Race/ethnicity (ref: Non-Hispanic White)					
Asian	0.01 (0.03)	−0.01 (−0.13)	−0.01 (−0.03)	−0.6 (−0.2)	−0.01 (−0.05)
Black	−0.001 (−0.006)	−0.08 (−0.23)	−0.02 (−0.07)	−0.02 (−0.07)	**0.10 (0.30)**
Hispanic/Latino	0.05 (0.18)	−0.04 (−0.09)	−0.005 (−0.02)	−0.02 (−0.07)	−0.01 (−0.02)
Unlisted	−0.02 (−0.12)	−0.01 (−0.05)	0.002 (0.02)	−0.05 (−0.32)	−0.02 (−0.14)
Self-reported social status	**−0.31 (−0.18)**	**−0.32 (−0.19)**	**−0.29 (−0.17)**	**0.12 (0.07)**	**−0.07 (−0.04)**
Political orientation (ref: Conservative)					
Moderate	0.04 (0.11)	0.05 (0.14)	0.07 (0.20)	**0.09 (0.24)**	−0.02 (−0.05)
Liberal	**0.09 (0.18)**	**0.10 (0.21)**	**0.12 (0.24)**	**0.14 (0.28)**	**0.08 (0.16)**
Apolitical/Other	0.04 (0.20)	0.05 (0.29)	0.04 (0.21)	0.003 (0.01)	0.00 (−0.02)
Cohort (ref: Sep. 1st–Oct. 31th 2020)					
Nov. 1st–Dec. 31th 2020	−0.07 (−0.15)	**−0.09 (−0.18)**	**−0.09 (−0.19)**	−0.02 (−0.04)	−0.03 (−0.06)
Jan. 1st–Feb. 29th 2020	**−0.10 (−0.24)**	**−0.08 (−0.20)**	**−0.10 (−0.26)**	−0.01 (−0.03)	0.01 (0.02)
Mar. 1st–Apr. 5st 2021	−0.04 (−0.14)	−0.03 (−0.11)	−0.05 (−0.15)	0.01 (0.02)	−0.01 (−0.04)
Having had COVID-19	0.02 (0.06)	0.04 (0.10)	−0.004 (−0.01)	0.02 (0.06)	−0.03 (−0.07)
Having had close contacts with COVID-19	0.05 (0.10)	0.06 (0.06)	**0.09 (0.19)**	**0.13 (0.27)**	**0.11 (0.22)**
Caretaker	0.06 (0.16)	0.05 (0.15)	**0.08 (0.26)**	−0.05 (−0.14)	0.02 (0.05)
Slope					
Age	0.11 (0.01)		0.05 (0.004)	−0.08 (−0.01)	
Gender (ref: Men)					
Women	0.01 (0.01)		0.02 (0.04)	−0.03 (−0.07)	
Self-describe	0.06 (0.47)		−0.03 (−0.26)	0.08 (0.59)	
Race/ethnicity (ref: Non-Hispanic White)					
Asian	−0.02 (−0.08)		−0.01 (−0.02)	−0.06 (0.20)	
Black	0.05 (0.15)		−0.04 (−0.2)	0.05 (0.15)	
Hispanic/Latino	−0.03 (−0.12)		−0.04 (−0.04)	−0.03 (−0.09)	
Unlisted	0.02 (0.15)		−0.01 (−0.05)	0.09 (0.61)	
Self-reported social status	**0.20 (0.12)**		**0.15 (0.09)**	−0.09 (−0.05)	
Political orientation (ref: Conservative)					
Moderate	−0.01 (−0.04)		−0.02 (−0.06)	−0.10 (−0.28)	
Liberal	**−0.10 (−0.19)**		−0.04 (−0.08)	−0.10 (−0.19)	
Apolitical/Other	0.01 (0.07)		0.03 (0.16)	−0.16 (−0.79)	
Cohort (ref: Sep. 1st–Oct. 31th 2020)					
Nov. 1st–Dec. 31th 2020	−0.06 (−0.11)		0.04 (0.09)	0.10 (0.20)	
Jan. 1st–Feb. 29th 2020	0.06 (0.16)		0.02 (0.05)	−0.04 (−0.10)	
Mar. 1st–Apr. 5st 2021	0.09 (0.30)		0.08 (0.27)	**0.22 (0.70)**	
Having had COVID-19	−0.07 (−0.19)		0.05 (0.12)	−0.07 (−0.19)	
Having had close contacts with COVID-19	0.05 (0.10)		−0.03 (−0.06)	0.10 (0.21)	
Caretaker	0.11 (0.31)		−0.01 (−0.03)	**−0.22 (−0.65)**	
5. Final Model [a]					
Intercept					
Impact of COVID-19 risk on daily activities	**0.32 (0.38)**	**0.26 (0.31)**	**0.36 (0.42)**	**0.07 (0.08)**	**−0.07 (−0.08)**
Slope					
Impact of COVID-19 risk on daily activities	**−0.18 (−0.21)**		**−0.16 (−0.19)**	−0.09 (0.11)	
Time-variant predictor					
Impact of pandemic on daily life at Wave 1	**0.16 (0.92)**	**0.10(0.56)**	**0.14 (0.72)**	**0.06 (0.10)**	0.01 (0.02)
					0.01 (0.02)
Impact of pandemic on daily life at Wave 2	**0.17 (0.92)**	**0.11(0.57)**	**0.15 (0.76)**	0.01 (0.01)	−0.02 (−0.04)
Impact of pandemic on daily life at Wave 3	**0.18 (0.98)**	**0.12(0.63)**	**0.16 (0.86)**	0.04 (0.06)	0.02 (0.02)

Note. The Means and Variances are unstandardized, and all other estimates are standardized results. Statistically significant results are in bold ($p < 0.05$).
[a] For depressive symptoms and cannabis use models, the final models are based on the intercept only model.

non-Hispanic White participants, from a later cohort, who had COVID-19 or COVID-19 close contact were less likely to retain in the survey. Therefore, our results should be interpreted with these factors in mind, limiting generalizability to the wider population, especially those who may be disproportionally impacted by the pandemic.

The data presented in the current study highlights the ongoing impact of the COVID-19 pandemic on mental health among U.S. adults. Despite gradual decreases in distress among some groups, stress, depression, anxiety, and substance use levels remain high, especially among individuals of lower social status and those whose daily activities

and caretaking responsibilities were disproportionally impacted by the pandemic. Our data indicate the importance of studies on the trajectory of mental health risk during ongoing phases of COVID and future pandemics. In addition to infection prevention, public health policies need to focus on long-lasting pandemic-related social factors, such as economic concerns and caretaking that continue to affect mental health.

CRediT authorship contribution statement

Xiangyu Tao: Conceptualization, Formal analysis, Writing – original draft. **Tingting Liu:** Methodology, Writing – original draft, Writing – review & editing. **Salvatore Giorgi:** Methodology, Investigation, Data curation, Writing – review & editing. **Celia B. Fisher:** Writing – review & editing. **Brenda Curtis:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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