Supplement Table 1 DSM-5-TR diagnostic criteria for a major depressive episode[1]

A. Five (or more) of the following symptoms have been present during the same two-week period and represent a change from previous functioning; at least one of the symptoms is either (1) depressed mood or (2) loss of interest or pleasure.
1) Depressed mood most of the day, nearly every day, as indicated by either subjective report (eg, feels sad, empty, hopeless) or observations made by others (eg, appears tearful). (NOTE: In children and adolescents, can be irritable mood.)
2) Markedly diminished interest or pleasure in all, or almost all, activities most of the day, nearly every day (as indicated by either subjective account or observation).
3) Significant weight loss when not dieting or weight gain (eg, a change of more than 5% of body weight in a month), or decrease or increase in appetite nearly every day. (NOTE: In children, consider failure to make expected weight gain.)
4) Insomnia or hypersomnia nearly every day.
5) Psychomotor agitation or retardation nearly every day (observable by others, not merely subjective feelings of restlessness or being slowed down).
6) Fatigue or loss of energy nearly every day.
7) Feelings of worthlessness or excessive or inappropriate guilt (which may be delusional) nearly every day (not merely self-reproach or guilt about being sick).
8) Diminished ability to think or concentrate, or indecisiveness, nearly every day (either by their subjective account or as observed by others).
9) Recurrent thoughts of death (not just fear of dying), recurrent suicidal ideation without a specific plan, or a suicide attempt or a specific plan for committing suicide.
B. The symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.
C. The episode is not attributable to the direct physiological effects of a substance or to another medical condition.
D. The occurrence of the major depressive episode is not better explained by schizoaffective disorder, schizophrenia, schizophreniform disorder, delusional disorder, or other specified and unspecified schizophrenia spectrum and other psychotic disorders.

E. There has never been a manic or hypomanic episode.

Supplement Table 2 Determine the severity of depression[1]

Severity
Mild
Individuals with mild major depression have ≥5 symptoms of depression **and** a PHQ-9 score of 5 to 9. They generally do not have: ▪ Marked distress or significant functional impairment ▪ Frequent suicidal or homicidal ideation or plans ▪ Psychotic features (eg, delusions or hallucinations) ▪ Catatonic features (eg, immobility, mutism, excessive purposeless motor activity) ▪ Significant aggressiveness
Moderate
Individuals with moderate major depression have ≥5 symptoms of depression **and** a PHQ-9 score of 10 to 19. They may have suicidal or homicidal ideation and plans. They generally do not have: ▪ Psychotic features (eg, delusions or hallucinations) ▪ Catatonic features (eg, immobility, mutism, excessive purposeless motor activity) ▪ Marked distress or functional impairment
Severe
Individuals with severe major depression have ≥7 symptoms of depression **or** a PHQ-9 score of ≥20 **or** any of the following: ▪ Psychotic features (eg, delusions or hallucinations) ▪ Catatonic features (eg, immobility, mutism, excessive purposeless motor activity) ▪ Marked distress or functional impairment ▪ Very likely to have suicidal or homicidal ideation and behavior (ie, a specific plan and intent to act upon it)
Symptoms of major depression
An episode of major depression consists of a period of at least 2 consecutive weeks with 5 or more of the following symptoms. Symptoms must be present nearly every day, and at least 1 of the symptoms must be depressed mood or anhedonia: ▪ Depressed mood ▪ Anhedonia (decreased interest or pleasure in activities previously considered enjoyable) ▪ Unintended change in appetite or weight ▪ Insomnia or hypersomnia ▪ Psychomotor agitation or significant slowing ▪ Decreased energy or fatigue ▪ Feelings of worthlessness or excessive guilt ▪ Poor concentration or new indecisiveness ▪ Recurrent thoughts about death or suicide

PHQ-9: 9-item Patient Health Questionnaire.

Supplement Table 3 Descriptive Statistics of Variables

Variable Name	Time	Mean	Min	Median	Max	Std.
Avg Daily Sunlight	-	16317.22	12306.63	15798.31	21701.97	1904.41
pctExcessiveDrinking	2019	19.26	7.00	19.00	30.00	3.16
Unemployment_rate	2021	4.77	1.80	4.50	16.20	1.49

As the US is such a big country with multiple climate categories, daily sunlight hours vary significantly among counties, with an annual mean of around 16,317 hours, impacting various aspects of life and environmental conditions. Notably, these disparities in sunlight exposure are of particular interest in the field of mental health, especially concerning depression disorders. Studies have documented the role of sunlight in regulating human circadian rhythms and serotonin levels, suggesting a link between sunlight exposure and mood disorders, including depression[2,3].

Supplement Table 4 Detailed Information on Variables

Variable Name	Detail	Timestamps	Spatial resolution	N	Source
severe_depression_per_100K *	Incidence of severe depression disorder per 100k population	2022	County	2152	Mental Health America (MHA)
2dose_Vac_Complete_5PlusPop_Pct (%) **	Change of the percentage of population over age 5 got two doses COVID vaccine from last year	2021, 2022	County	3283	Centers for Disease Control and Prevention (CDC)

covid_case_per100k **	Number of Covid cases per 100k population	2021,2022	County	3332	Johns Hopkins University
Age_524_pct (%)	Percentage of population age between 5 to 24	2021	County	3143	US Census
Avg Daily Sunlight (KJ/m2)	Average daily sunlight power	-	County	3332	North America Land Data Assimilation System (NLDAS)
Mental Health Provider Rate_log	Mental health providers per 100k population (logged)	2021	County	3193	Centers for Medicare & Medicaid Services (CMS)
pctExcessiveDrinking_log	Percentage of adults reporting binge or heavy drinking (age-adjusted, logged)	2019	County	3193	Behavioral Risk Factor Surveillance System
Unemployment_rate (%)	The number of unemployed divided by the labor force	2021	County	3277	U.S. Bureau of Labor Statistics

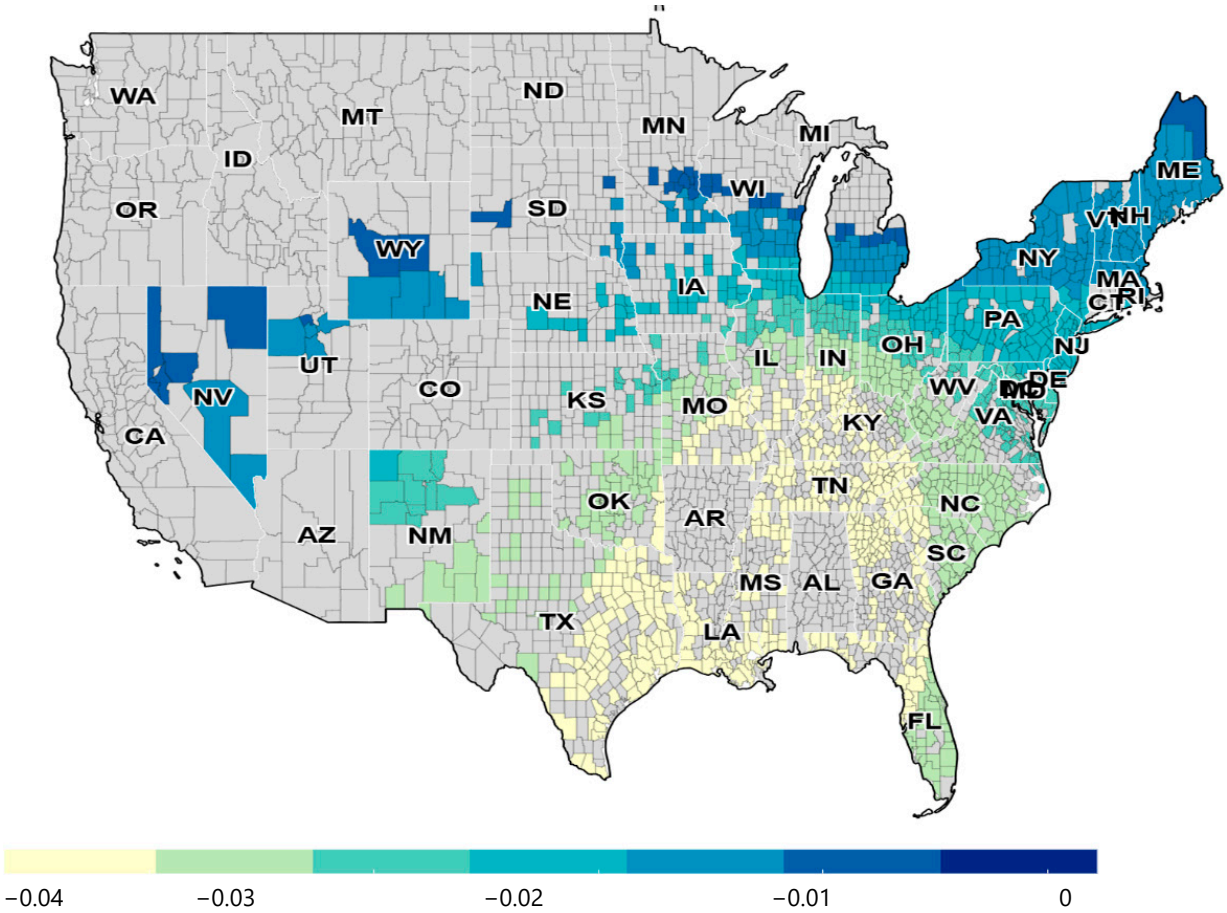
Note: * denotes dependent variable, ** denotes main independent variables, others are control variables.

Supplement Table 5 VIF Results on Independent Variables

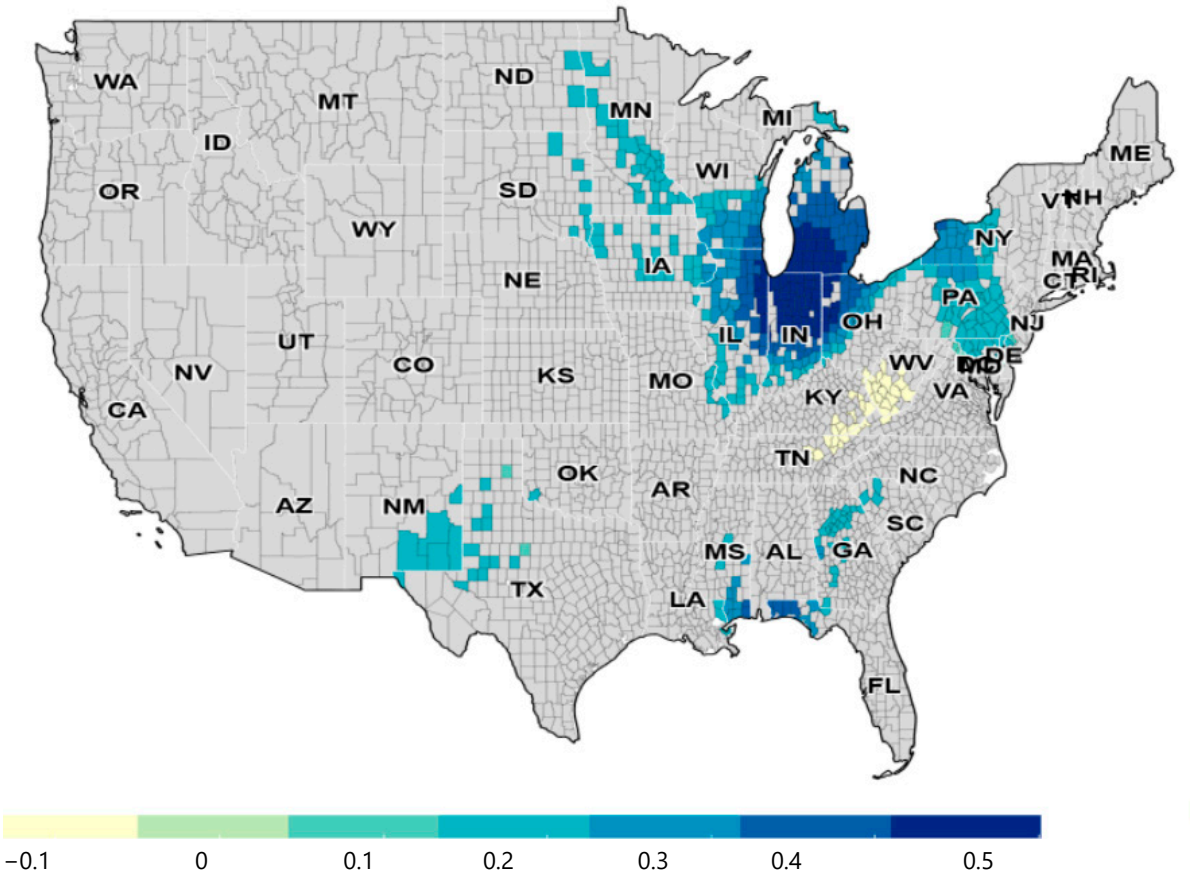
Variable	VIF	Tolerance	Implied R^2
Median_Household_Income_2020_log	1.63	0.61	0.39
2dose_Vac_Complete_5PlusPop_Pct	1.49	0.67	0.33
pctExcessiveDrinking_log	1.31	0.76	0.24
Unemployment_rate_2021	1.31	0.76	0.24
Avg Daily Sunlight (KJ/m²)	1.18	0.85	0.15
covid_case_per100k_2021	1.18	0.85	0.15
Age_524_pct	1.08	0.92	0.08

Supplement Table 6 OLS Results on all Variables

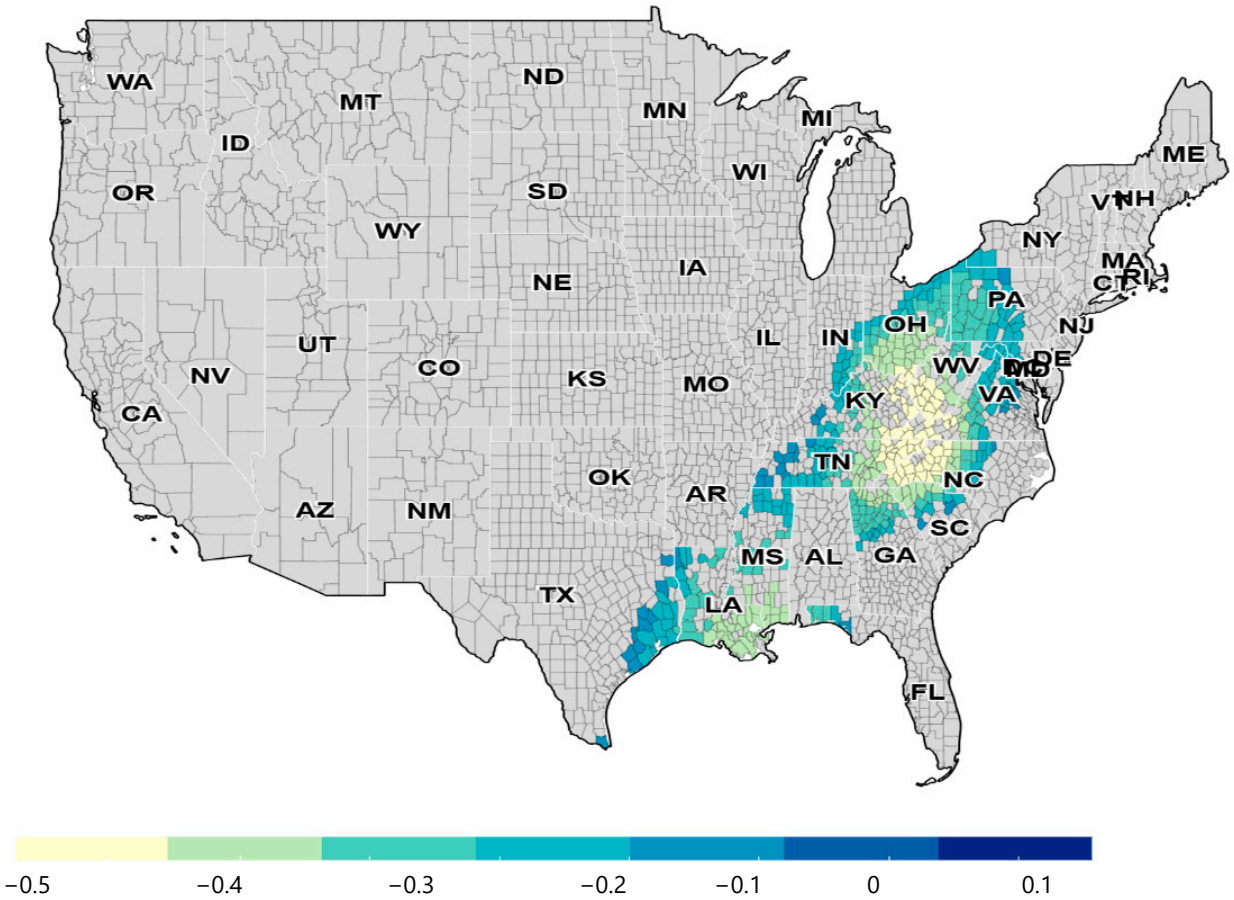
Variable	Estimate	Std. Error	t	p-value
Intercept	0	0.024	0	1
Unemployment_rate_2021	-0.156	0.028	-5.48	0
2dose_Vac_Complete_5PlusPop_Pct	-0.054	0.037	-1.463	0.143
Median_Household_Income_2020_float	-0.076	0.044	-1.715	0.086
Pct_bachelor_plus_2020	0.038	0.056	0.68	0.496
covid_case_per100k_2021	0.085	0.028	3.019	0.003
Age_524_pct	0.118	0.03	3.919	0
pctExcessiveDrinking_log	-0.2	0.032	-6.282	0
Mental Health Provider Rate_log	-0.097	0.031	-3.157	0.002
pctSmokers_log	0.01	0.057	0.173	0.863
pctAdultObesity_log	0.031	0.042	0.742	0.458
pctPhysicallyInactive_log	-0.046	0.052	-0.87	0.384
Avg Daily Sunlight (KJ/m2)	-0.122	0.032	-3.833	0
Fem_Pct	0.004	0.027	0.146	0.884



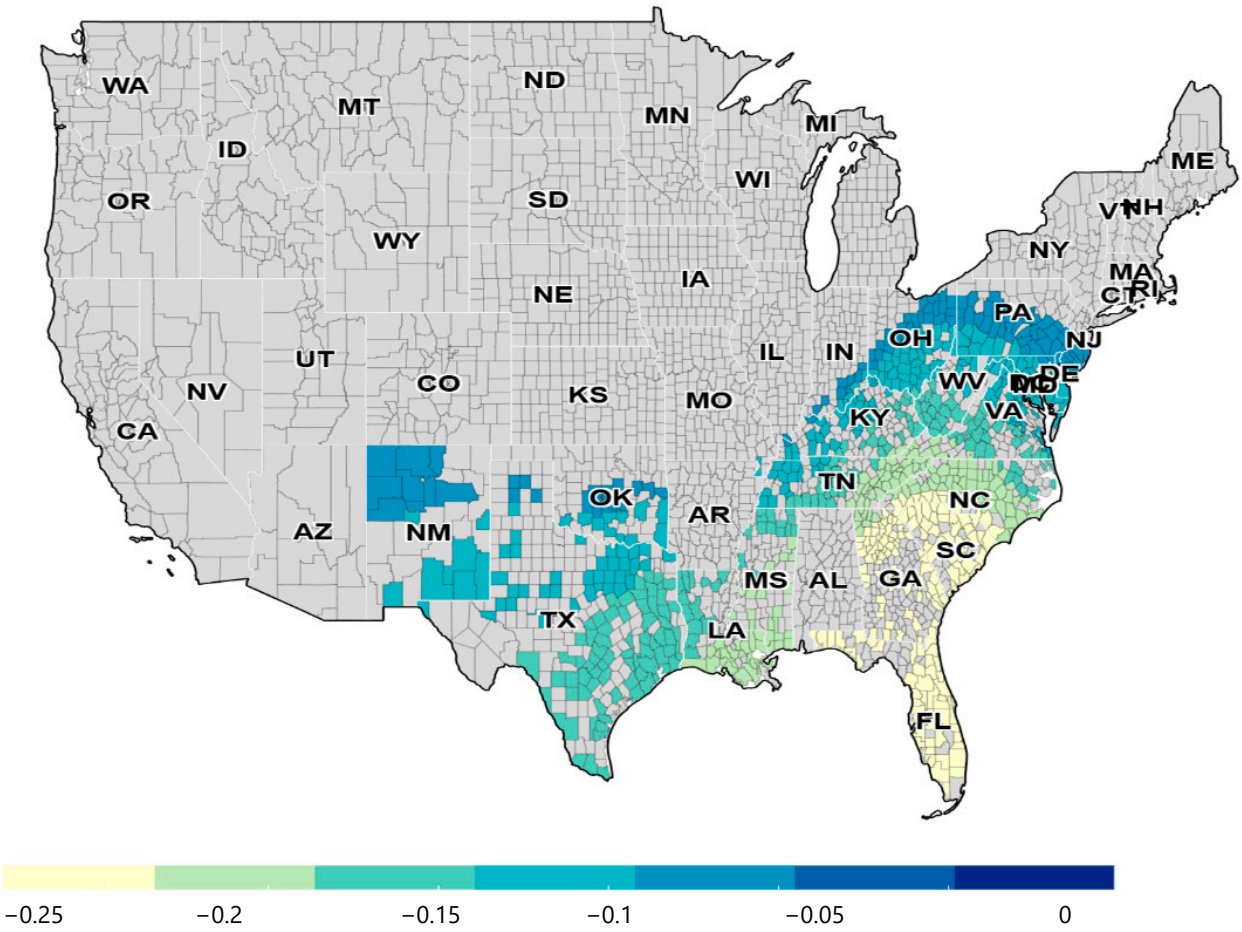
Supplement Figure 1 Spatial distribution of the coefficient of vaccination rate with p >0.1 masked



Supplement Figure 2 Spatial distribution of the coefficient of COVID-19 case rates with p >0.1 masked



Supplement Figure 3 Spatial distribution of the coefficient of COVID-19 case rates with p >0.1 masked



Supplement Figure 4 Spatial distribution of the coefficient of unemployment rates with p >0.1 masked

Reference

1. Association AP. *Diagnostic and statistical manual of mental disorderss (5th ed., text rev.)*. 2022.
2. Kim SY, Bang M, Wee JH, et al. Short-and long-term exposure to air pollution and lack of sunlight are associated with an increased risk of depression: A nested case-control study using meteorological data and national sample cohort data. *Science of the Total Environment*. 2021;757:143960.
3. Wang J, Wei Z, Yao N, Li C, Sun L. Association Between Sunlight Exposure and Mental Health: Evidence from a Special Population Without Sunlight in Work. *Risk Management and Healthcare Policy*. 2023:1049-1057.