



Factors Associated with Long COVID Recovery among US Adults

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ABSTRACT

BACKGROUND: While factors associated with long COVID (LC) continue to be illuminated, little is known about recovery. This study used national survey data to assess factors associated with recovery from LC.

METHODS: We used data from the 2022 National Health Interview Survey, a cross-sectional sample of non-institutionalized US adults. Survey analysis was used to account for oversampling and nonresponse bias and to obtain nationally representative estimates. A multivariable logistic regression model was used to identify potential predictors of LC recovery.

RESULTS: Among those reporting ever having COVID-19, 17.7% or an estimated 17.5 million American adults reported ever having LC, and among those with LC, 48.5% or an estimated 8.5 million reported having recovered. Multivariable logistic regression analysis showed that Hispanic adults were significantly more likely than White adults to report recovery from LC. At the same time, those with severe COVID-19 symptoms and those who had more than a high school degree, were aged 40 years or older, or were female were less likely to report recovery.

CONCLUSION: Significant variations in LC recovery were noted across age, sex, race and ethnicity, education, and severity of COVID-19 symptoms. Further work is needed to elucidate the causes of these differences and identify strategies to increase recovery rates.

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BACKGROUND

Long COVID (LC), a wide-ranging condition characterized by myriad symptoms that affect daily functioning, continues to pose a significant public health burden.¹ While extensive research has been conducted on the pathophysiology of LC,² little is known about its recovery. Characterizing those who recover from LC may inform strategies for addressing the condition and managing its symptoms. In this study, we used a nationally representative survey to estimate recovery rates from LC and identify factors associated with recovery.

METHODS

We used data from the 2022 National Health Interview Survey (NHIS), a cross-sectional sample of noninstitutionalized US adults with a response rate of 47.7%.³ We employed the sampling weights provided in the 2022 NHIS data set to account for oversampling and nonresponse bias and to obtain nationally representative estimates.

We restricted our analysis to adults 18 years or older who self-reported either a positive COVID-19 test, defined as an affirmative response to the question, “Did you ever take a test that showed you had coronavirus or COVID-19?” or a doctor’s diagnosis of COVID-19, defined as an affirmative response to the question, “Has a doctor or other health professional ever told you that you had or likely had coronavirus or COVID-19?” LC was defined as an affirmative response to the question, “Did you have any symptoms lasting 3 months or longer that you did not have prior to having coronavirus or COVID-19?” Recovery from LC was defined as an affirmative response to the previous question and a negative response to the question, “Do you have symptoms NOW?” (asked immediately after the previous question, as a follow-up to those ever-reporting COVID-19).

We then compared sociodemographic characteristics (age, sex, race and ethnicity, employment status, health insurance coverage, urbanization level, educational attainment, and COVID-19 symptom severity) between adults with LC who did and did not recover using the Rao-Scott χ^2 test for categorical variables. A multivariable logistic regression model was used to identify independent factors associated with LC recovery. Covariates that were not significantly different between both groups in the baseline sociodemographic analysis were excluded from the logistic regression model. Covariates were chosen based on prior knowledge of sociodemographic factors associated with COVID-19.⁴ A 2-sided $P < .05$ was significant. Analyses were conducted using R, version 4.3.0. This study was exempt from review by the Yale University Institutional Review Board, as NHIS data are publicly available and de-identified. We followed the STROBE (Strengthening the

Reporting of Observational Studies in Epidemiology) guideline.

RESULTS

Of the 27,651 adults in our study sample, 10,131 (36.6%) reported ever having COVID-19, corresponding to a national estimate of over 100 million Americans. Of that group, 1797 (17.7%), or an estimated 17.5 million, reported ever having LC. Among those with LC, 872 (48.5%), or an estimated 8.5 million, reported having recovered. Overall, LC recovery rates were higher among adults under 40 years of age and those who were male, Hispanic, non-Hispanic Black, non-Hispanic Asian, or employed; had less than a high school degree; or reported mild or moderate COVID-19 symptoms (Table).

In our multivariable logistic regression analysis, Hispanic adults were significantly more likely than White adults to report recovery from LC (odds ratio [OR] 1.44; 95% confidence interval [CI], 1.07-1.95) (Figure). In contrast, those with severe acute COVID-19 symptoms were least likely to report recovery (OR 0.58; 95% CI, 0.43-0.78), followed by individuals who had more than a high school degree (OR 0.61; 95% CI, 0.39-0.96), were aged 40-64 years (OR 0.72; 95% CI, 0.56-0.91) or 65 years and older (OR 0.68; 95% CI, 0.50-0.94), or were female (OR 0.73; 95% CI, 0.58-0.93).

DISCUSSION

In this nationwide cross-sectional study, nearly 1 in 5 adults with a COVID-19 diagnosis reported ever having LC; of those, about half recovered. This result is the first nationally representative estimate of LC recovery. We also found that severe COVID-19 symptoms were associated with a lower likelihood of LC recovery, consistent with existing literature.⁵ The inverse correlation between COVID-19 symptom severity and the likelihood of recovery from LC suggests that effective early management of initial COVID-19 symptoms, which are correlated to the risk and severity of LC,⁶ may also expedite the LC recovery process. Adjusting for the severity of COVID-19 infection, we found that age, sex, race and ethnicity, and education were independently associated with recovery.

Demographic differences in LC recovery rates indicate the possibility of underlying socioeconomic and cultural factors influencing LC outcomes. Differences in reporting, treatments, exposures, or access to care may explain these disparities. In addition, some groups may perceive and report symptoms differently.

CLINICAL SIGNIFICANCE

- In a nationwide sample, nearly 1 in 5 reporting COVID developed long COVID; of these, about half recovered.
- Severe symptoms during acute COVID-19 infection were associated with a lower likelihood of recovery from long COVID.
- Recovery rates varied by age, sex, race and ethnicity, and education level.

Table Sociodemographic Characteristics of Adults Currently with and Recovered from LC*

Characteristic	Adults, n (%) [95% CI] [†]		P Value [‡]
	Not Recovered (n = 919)	Recovered (n = 872)	
Age (years)			.001
18-39	268 (35) [31-39]	339 (44) [41-48]	
40-64	437 (50) [46-54]	374 (44) [41-48]	
≥65	213 (15) [13-17]	159 (12) [10-14]	
Sex			.01
Male	295 (33) [30-37]	341 (40) [36-45]	
Female	624 (67) [63-70]	531 (60) [55-64]	
Race and ethnicity			.02
Asian, NH	21 (2) [1-3]	23 (3) [2-4]	
Black, NH	75 (8) [7-11]	86 (10) [8-13]	
Hispanic	133 (17) [14-21]	187 (24) [20-28]	
Other, NH	29 (4) [2-6]	32 (5) [3-8]	
White, NH	661 (69) [64-72]	544 (59) [55-63]	
Employment status			.048
Unemployed	352 (36) [33-40]	287 (31) [27-35]	
Employed	530 (64) [60-67]	555 (69) [65-73]	
Health insurance coverage			.045
Public	281 (28) [25-31]	231 (24) [21-28]	
Private	582 (65) [61-68]	558 (65) [61-69]	
Uninsured	55 (7) [6-10]	82 (11) [9-14]	
Urbanization level			.20
Nonmetropolitan	187 (17) [14-20]	129 (14) [11-18]	
Metropolitan	732 (83) [80-86]	743 (86) [82-89]	
Educational attainment			.01
< High school degree	54 (7) [5-10]	74 (12) [9-15]	
≥ High school degree	863 (93) [90-95]	796 (88) [85-91]	
COVID-19 symptom severity			< .001
Mild symptoms	175 (18) [15-21]	214 (24) [21-27]	
Moderate symptoms	376 (43) [39-47]	381 (45) [42-49]	
Severe symptoms	368 (39) [35-43]	276 (30) [27-34]	

CI = confidence interval; LC = long COVID; NH = non-Hispanic.
*Individuals reporting to ever have LC with an uncertain or missing response to the current LC symptoms question (n = 6, 0.3%) were excluded from the sample population.
[†]Respondent counts are unweighted; percentage estimates and 95% CIs are weighted.
[‡]Pearson's Chi-squared tests with second-order Rao-Scott correction.

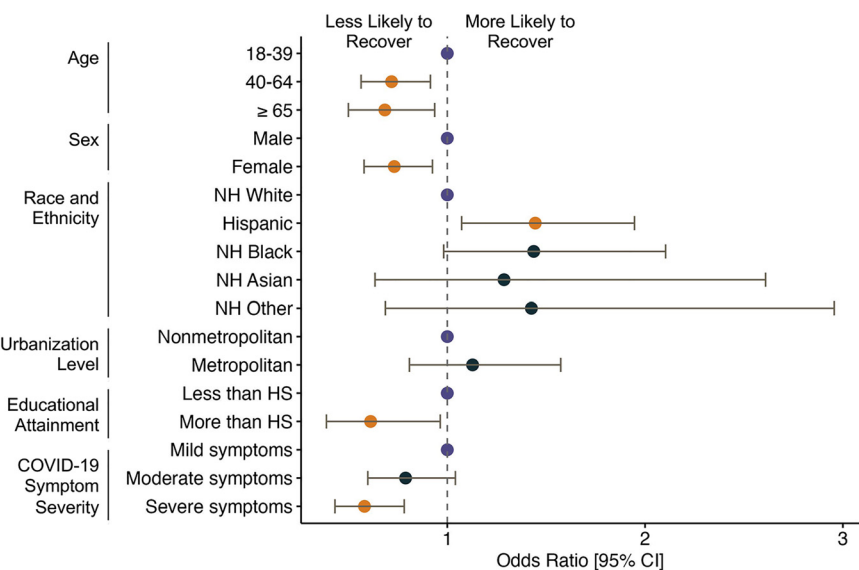


Figure Adjusted odds ratios of factors associated with LC recovery. Significant (Wald test $P < .05$) odds ratios are indicated in orange, reference levels are indicated in purple, and all other odds ratios are indicated in blue. HS = high school; LC = long COVID; NH = non-Hispanic.

This study has several limitations. First, there is a lack of information on the timing of acute COVID-19 infection attributable to LC symptoms and recovery onset. The lack of timing data may confound results, as we cannot be certain whether identified factors are associated with LC recovery or time since COVID-19 infection. However, there is no evidence that the demographic factors identified should be correlated with the timing of the LC. Second, misclassification and underreporting may be present in the self-reported survey data; however, self-reporting remains the sole method for identifying LC and its recovery. Third, LC was narrowly defined; adopting the broader definition of LC provided by the Centers for Disease Control and Prevention that includes new, returning, or ongoing health problems experienced 4 or more weeks after COVID-19 infection⁷ may impact the reported prevalence and improve understanding of recovery.

Based on a nationally representative sample, the study's key finding is that half of the individuals with LC reported having recovered, with rates that varied by sociodemographic characteristics. As LC continues to strain health care systems worldwide,⁸ it is important to further study recovery patterns to mitigate the long-term impacts of the condition.

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References

1. Raveendran AV, Jayadevan R, Sashidharan S. Long COVID: an overview. *Diabetes Metab Syndr* 2021;15(3):869–75.
2. Davis HE, McCorkell L, Vogel JM, Topol EJ. Long COVID: major findings, mechanisms and recommendations. *Nat Rev Microbiol* 2023;21(3):133–46.
3. Centers for Disease Control and Prevention, National Center for Health Statistics. *National Health Interview Survey: 2022 NHIS*. Available at: <https://www.cdc.gov/nchs/nhis/2022nhis.htm>. Accessed April 1, 2024.
4. Taquet M, Dercon Q, Luciano S, Geddes JR, Husain M, Harrison PJ. Incidence, co-occurrence, and evolution of long-COVID features: a 6-month retrospective cohort study of 273,618 survivors of COVID-19. *PLoS Med* 2021;18(9):e1003773.
5. Shen Q, Joyce EE, Ebrahimi OV, et al. COVID-19 illness severity and 2-year prevalence of physical symptoms: an observational study in Iceland, Sweden, Norway and Denmark. *Lancet Reg Health Eur* 2023;35:100756.
6. Menezes AS Jr., Botelho SM, Santos LR, Rezende AL. Acute COVID-19 syndrome predicts severe long COVID-19: an observational study. *Cureus* 2022;14(10):e29826.
7. Centers for Disease Control and Prevention (CDC). Long COVID or post-COVID conditions. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/long-term-effects/index.html>. Accessed April 1, 2024.
8. Katz GM, Bach K, Bobos P, et al. Understanding how post-COVID-19 condition affects adults and health care systems. *JAMA Health Forum* 2023;4(7):e231933.