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ORIGINAL ARTICLE | GEOGRAPHIC DISPARITIES

State and Metropolitan Area Disparities in Long COVID-19 and Related Symptoms among US Adults, June-October 2022

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ABSTRACT

Background: Little research exists on sociodemographic and geographic inequalities in Long COVID, defined as COVID-19 symptoms lasting 3 months or longer. Using the latest nationally representative data, we examine geographic disparities in prevalence of Long COVID and severe COVID symptoms among United States (US) adults aged ≥18 years.

Methods: We analyzed five consecutive rounds of the US Census Bureau's Household Pulse Survey from June 1 to October 17, 2022 (N=108,064). Using multivariable logistic regression and health disparity indices, we modeled disparities in Long COVID and severe COVID symptoms by state and metropolitan area, controlling for race/ethnicity, socioeconomic status, health insurance, and other demographic characteristics.

Results: During June–October 2022, an estimated 35.4 million or 32.2% of COVID patients in the US reported developing Long COVID; and 15.2 million or 13.8% of COVID patients reported experiencing severe COVID symptoms. The prevalence of Long COVID ranged from 24.0% in the District of Columbia (DC), 25.4% in Hawaii to 39.2% in Alabama, 39.9% in Wyoming, and 43.6% in West Virginia. Adjusted for covariates, adults with COVID-19 diagnosis in Alabama, Wyoming, and West Virginia had 48-178% higher adjusted odds of developing Long COVID than their counterparts in DC. Adults with COVID-19 diagnosis in Alabama, Arkansas, Colorado, Iowa, Kentucky, Mississippi, Montana, North Dakota, South Dakota, Texas, Utah, Virginia, Wyoming, and West Virginia had 2.0-2.5 times higher adjusted odds of experiencing severe COVID symptoms than their counterparts in Vermont. Large disparities in prevalence of Long COVID and severe COVID symptoms existed among the 15 largest metropolitan areas of the US, with the prevalence of Long COVID ranging from 21.9% in San Francisco to 38.0% in Riverside, California. Socioeconomic, demographic and health insurance characteristics explained 34% of the state-level disparity and 45% of the metropolitan-area disparity in Long COVID prevalence.

Conclusion and Implications for Translation: Marked geographic disparities existed, with COVID patients/survivors in the Southeast, Southwest, and Northern Plains states being at substantially higher risks of developing Long COVID and severe COVID symptoms. Equitable access to care and support services among patients with Long COVID is critical to reducing inequities in COVID-related health outcomes.

Keywords: Long COVID • COVID-19 Pandemic • Disease Severity • Geographic Disparities • Social Determinants

1. Introduction

The coronavirus disease (COVID-19) pandemic has had a devastating impact on people's health and wellbeing in the US and globally since the start of the pandemic three years ago, resulting in massive social and economic disruptions and costs (estimated at 16 trillion dollars for the US alone), social isolation, mental health problems, reduced access to healthcare and welfare services, excess premature mortality, and declines in life expectancy.[1–10] US has been greatly affected by the pandemic, with 101.4 million confirmed COVID-19 cases and 1.1 million deaths as of January 10, 2023,[8] in comparison to 660,378,145 confirmed cases and 6,691,495 deaths globally.[2]

Although the disease burden associated with COVID-19 cases, deaths, and hospitalizations has been substantial,[11] Long COVID has affected nearly 36 million COVID-19 survivors in the US, leading to considerable suffering and disabilities.[12–14] Long COVID, also called post-COVID conditions, is considered a "multifaceted disease," with COVID-19 symptoms lasting 3 months or longer, and sometimes manifesting as new chronic conditions, including heart disease, diabetes, kidney disease, hematologic disorders, and mental and neurological conditions.[13–16]

Among the most-commonly-reported symptoms of Long COVID include fatigue, chest pain, trouble breathing and cough, trouble thinking and concentrating ("brain fog"), headaches, dizziness, sleep problems, muscle aches, stomach pain, and diarrhea.[16–18] A newly released study attributed 3,544 US deaths to Long COVID between January 2020 and July 2022.[19] Long COVID has also had a substantial economic impact, with 4 million Americans reported to be out of work due to Long COVID, costing $170 billion to $230 billion annually in lost wages, and significant income loss, shortage of workers, and a surge in inflation.[20,21]

Although inequalities in the prevalence of Long COVID among US adults have been documented to some extent by such sociodemographic factors as age, gender, race/ethnicity, education, and household income,[12] geographic disparities in Long COVID and the related disease severity have not yet been analyzed. Geographic disparities in Long COVID may be due to differences in socioeconomic and demographic factors, health-risk behaviors, state- and community-specific policies in preventive COVID-related behaviors such as social and physical distancing, face-mask use, COVID-19 vaccinations, and access to health insurance and primary/specialized care.[9,22–24]

Analyses of geographic disparities in Long COVID are critical to identifying underserved areas and populations with a disproportionate disease burden and to demonstrate the need for a more equitable access to healthcare, treatment, and social services to promote health equity and to reduce disparities in COVID-related health outcomes.[5,9,13–15,22,25,26] To address the existing gaps in research and to provide new insights into surveillance and epidemiology of Long COVID, we use a large nationally representative survey to examine state and metropolitan area disparities in Long COVID and disease severity among US adults aged ≥18 years during the ongoing coronavirus pandemic.

2. Methods

2.1. Data

We used pooled data from five consecutive samples of the US Census Bureau's Household Pulse Survey (HPS) conducted during June to October 2022. The five independent HPS samples that included information on COVID-19 diagnosis, Long COVID, and severity of COVID symptoms among adults aged ≥18 years were: Week 46, June 1–13; Week 47, June 29–July 11; Week 48, July 27–August 8; Week 49, September 14–28; and Week 50, October 5–17, 2022.[27] The HPS is a national sample household survey in which data on socioeconomic, demographic, physical and mental health, food insecurity, childcare, and healthcare characteristics, including health insurance coverage, COVID-19 diagnosis and vaccination, and access to telehealth during the COVID-19 pandemic are collected in near real time via email and internet. The HPS was developed as a rapid response survey, in partnership with several federal statistical agencies, to track social and economic impacts of the COVID-19 pandemic on American households on a weekly or a bi-weekly basis.[28,29] Information collected in the survey is based on self-reports by respondents aged 18 years and older. The HPS employs a systematic sample design, ensuring its representativeness of the US civilian non-institutionalized population. Substantive and methodological details of the survey are available elsewhere. [27–29]

2.2. Measurement of the Outcome Variables: Long COVID and COVID Disease Severity

We used two COVID-related binary outcome variables. The first outcome variable, Long COVID, was based on the question, "Did you have any symptoms lasting 3 months or longer that you did not have prior to having coronavirus or COVID-19? Long term symptoms may include tiredness or fatigue, difficulty thinking, concentrating, forgetfulness, or memory problems (sometimes referred to as "brain fog," difficulty breathing or shortness of breath, joint or muscle pain, fast-beating or pounding heart (also known as heart palpitations), chest pain, dizziness on standing, menstrual changes, changes to taste/smell, or inability to exercise." COVID patients responding "yes" were defined as having Long COVID and those with "no" response were considered not to have Long COVID.

The second outcome variable, disease severity (i.e., severe COVID symptoms), was based on the question, "How would you describe your coronavirus symptoms when they were at their worst?" Respondents who reported severe symptoms were defined as having severe COVID symptoms, and those reporting no, mild or moderate symptoms as not having severe symptoms.

The pooled sample size from June-October 2022 HPS was 108,064 adults aged ≥18 years for whom information on the outcome variables and the covariates was available.[27]

2.3. Measurement of Geographic Area and Covariates

The independent variable of interest was the respondent's state or Metropolitan Statistical Area (MSA) of residence at the time of the survey.[27] Data were available for all 50 states and DC and the 15 largest MSAs in the US, as shown in Tables 1-2 and Figures 1-2.

Based on previous research on COVID-related outcomes and the social determinants of health framework, we selected the following covariates for the two outcome variables: age (18-24 years, 25-34, 35-44, 45-54, 55-64, 65-74, ≥75), race/ethnicity (non-Hispanic White, non-Hispanic Black/African American, Asian, Hispanic, other and multiple races), gender (male, female), lesbian, gay, bisexual, and transgender (LGBT) status (lesbian or gay, bisexual, transgender, straight/heterosexual, other), marital status (married, widowed, divorce/separated, single), region of residence (Northeast, South, Midwest, West), educational attainment (less than high school, high school, some college, college degree, graduate degree or higher), annual household income (<$25,000; 25,000-34,999; 35,000-49,999; 50,000-74,999; 75,000-99,999; 100,000-149,999; 150,000-199,999; ≥200,000; unknown), housing tenure (homeowner, renter), and health insurance status (insured, not insured).[6,9,12,22,27,30]

2.4. Statistical Methods

Given the binary outcome variables, multivariable logistic regression was used to model disparities in COVID-related outcomes by geographic area after controlling for socioeconomic, demographic, and health care characteristics. The Chi-square statistic tested the overall association between each covariate and Long COVID or severe COVID

Table 1: Unadjusted and Adjusted Weighted Prevalence (%), Odds of Long COVID, and Health Disparity Indices in 50 States and the District of Columbia, US Adults Aged ≥18 Years: The Household Pulse Survey, Weeks 46 to 50, June 1 - October 17, 2022 (N=107,234)

	Unadjusted Prevalence		Unadj. Odds Ratio and 95% Confidence Interval			Adjusted Odds Ratio and 95% Confidence Interval			Adjusted Prevalence	
	%	SE	OR	Lower	Upper	AOR	Lower	Upper	%	SE
United States	32.20	0.29								
Alaska	34.73	2.28	1.69	1.15	2.48	1.27	0.85	1.92	34.73	2.27
Alabama	39.15	1.82	2.04	1.42	2.93	1.48	1.01	2.18	38.01	1.78
Arkansas	37.91	1.78	1.94	1.35	2.78	1.38	0.94	2.03	36.48	1.70
Arizona	35.42	1.61	1.74	1.22	2.48	1.21	0.83	1.77	33.61	1.55
California	29.42	1.11	1.32	0.94	1.87	0.95	0.66	1.38	28.79	1.05
Colorado	35.09	1.54	1.71	1.20	2.44	1.36	0.93	1.99	36.19	1.51
Connecticut	27.85	1.51	1.22	0.85	1.75	0.99	0.67	1.45	29.46	1.56
District of Columbia	23.97	3.05	1.00	Reference		1.00	Reference		29.73	3.57
Delaware	25.68	1.88	1.10	0.75	1.60	0.86	0.58	1.29	26.90	1.86
Florida	31.97	1.37	1.49	1.05	2.12	1.07	0.73	1.55	31.02	1.30
Georgia	34.10	1.58	1.64	1.15	2.34	1.27	0.87	1.86	34.68	1.55
Hawaii	25.43	2.16	1.08	0.73	1.61	0.85	0.55	1.29	26.52	2.24
Iowa	31.99	1.59	1.49	1.04	2.13	1.13	0.77	1.66	32.25	1.56
Idaho	36.65	1.67	1.83	1.28	2.62	1.34	0.91	1.96	35.83	1.60
Illinois	32.73	1.46	1.54	1.08	2.20	1.22	0.84	1.78	33.81	1.45
Indiana	36.15	1.51	1.80	1.26	2.55	1.35	0.92	1.96	35.93	1.46
Kansas	32.61	1.44	1.53	1.08	2.18	1.16	0.79	1.69	32.74	1.43
Kentucky	35.02	1.85	1.71	1.19	2.46	1.23	0.83	1.81	33.93	1.77
Louisiana	36.31	1.80	1.81	1.26	2.60	1.32	0.90	1.94	35.47	1.75
Massachusetts	26.68	1.24	1.15	0.81	1.64	0.94	0.64	1.36	28.47	1.27
Maryland	28.51	1.53	1.26	0.88	1.81	1.06	0.72	1.55	30.86	1.58
Maine	27.20	2.11	1.19	0.80	1.75	0.89	0.59	1.34	27.41	2.08
Michigan	31.18	1.32	1.44	1.01	2.04	1.12	0.77	1.63	32.09	1.32
Minnesota	30.25	1.40	1.38	0.97	1.96	1.11	0.76	1.62	31.88	1.42
Missouri	35.72	1.60	1.76	1.24	2.51	1.34	0.92	1.96	35.83	1.56
Mississippi	38.23	1.98	1.96	1.36	2.83	1.39	0.94	2.06	36.69	1.89
Montana	33.79	2.13	1.62	1.11	2.36	1.19	0.80	1.78	33.35	2.00
North Carolina	33.51	1.75	1.60	1.11	2.30	1.19	0.81	1.75	33.29	1.73
North Dakota	36.27	2.01	1.81	1.25	2.61	1.38	0.93	2.04	36.39	1.96
Nebraska	34.32	1.52	1.66	1.16	2.36	1.25	0.85	1.83	34.31	1.52
New Hampshire	28.70	1.73	1.28	0.88	1.84	0.99	0.67	1.47	29.57	1.71
New Jersey	26.92	1.52	1.17	0.81	1.68	0.93	0.63	1.37	28.30	1.57
New Mexico	38.54	1.85	1.99	1.38	2.86	1.29	0.88	1.91	35.06	1.76
Nevada	34.36	1.78	1.66	1.15	2.39	1.14	0.78	1.68	32.43	1.67
New York	31.16	1.59	1.44	1.00	2.06	1.11	0.76	1.63	31.87	1.60
Ohio	32.76	1.72	1.55	1.08	2.22	1.17	0.80	1.72	32.92	1.65

(Contd...)

Table 1: *(Continued)*

	Unadjusted Prevalence		Unadj. Odds Ratio and 95% Confidence Interval			Adjusted Odds Ratio and 95% Confidence Interval			Adjusted Prevalence	
	%	SE	OR	Lower	Upper	AOR	Lower	Upper	%	SE
Oklahoma	38.56	1.57	1.99	1.40	2.83	1.40	0.96	2.05	36.81	1.53
Oregon	32.21	1.49	1.51	1.06	2.15	1.10	0.75	1.60	31.58	1.50
Pennsylvania	30.34	1.47	1.38	0.97	1.97	1.06	0.73	1.55	30.90	1.43
Rhode Island	30.98	2.19	1.42	0.97	2.09	1.02	0.68	1.54	30.22	2.10
South Carolina	35.22	1.64	1.72	1.21	2.46	1.30	0.89	1.90	35.14	1.56
South Dakota	35.15	2.12	1.72	1.18	2.50	1.31	0.88	1.94	35.28	2.01
Tennessee	36.38	1.56	1.81	1.27	2.58	1.39	0.95	2.02	36.58	1.52
Texas	33.22	1.26	1.58	1.12	2.23	1.11	0.77	1.61	31.83	1.19
Utah	35.77	1.44	1.77	1.24	2.51	1.35	0.93	1.96	35.93	1.36
Virginia	28.87	1.46	1.29	0.90	1.84	1.05	0.72	1.54	30.71	1.51
Vermont	26.26	2.20	1.13	0.76	1.68	0.87	0.57	1.31	26.96	2.14
Washington	28.57	1.19	1.27	0.90	1.80	0.97	0.67	1.41	29.19	1.16
Wisconsin	28.96	1.57	1.29	0.90	1.86	0.99	0.67	1.46	29.57	1.64
West Virginia	43.55	2.22	2.45	1.69	3.55	1.78	1.20	2.65	42.20	2.14
Wyoming	39.94	2.11	2.11	1.46	3.06	1.52	1.02	2.26	38.62	2.03
Health disparity indices										
CV	13.07								10.36	
RMSD	9.82								7.22	
CV(RMSD)	40.99								27.24	

SE= standard error; OR=odds ratio; AOR=adjusted odds ratio; RMSD=root-mean-square-deviation; CV=coefficient of variation. Chi-square statistics for testing the overall association between state and prevalence of Long COVID were statistically significant at p<0.01. Odds ratios (ORs), estimated by logistic model, were unadjusted for the effects of other covariates. Adjusted odds ratios (AORs) were estimated by logistic regression model that controlled for age, race/ethnicity, gender, LGBT status, marital status, region of residence, education, household income, housing tenure, and health insurance status.

symptoms prevalence, while the two-sample t-test assessed differences in prevalence between any two geographic areas. To account for the complex sample design of the HPS, SUDAAN software was used to conduct all statistical analyses, including the logistic modeling procedure RLOGIST.[31] Adjusted prevalence estimates for the two outcome variables were derived by the logistic model at the mean values of the covariates.

We used two health disparity indices, the coefficient of variation and the root-mean-square-deviation (RMSD) to summarize geographic disparities in Long COVID and severe COVID symptoms among 50 states and DC or among 15 metropolitan areas.[32–34] We used root-mean-square-deviation (RMSD) as a summary measure of geographic disparities among 50 states and DC or among 15 metropolitan areas.[32,33] The RMSD, developed by Singh and colleagues, is similar to the square root of the variance, except that the average-squared-deviations are calculated using a "standard" estimate other than the sample mean. The RMSD is given by the formula:

$$\text{RMSD} = \text{SQRT}\left\{\sum i \frac{\left(C_{ri} - C_{rl}\right)^2}{I}\right\}$$

where C_{ri} is the prevalence of Long COVID or severe COVID symptoms for the *i*th state (i=1,2,…,51) or MSA (i=1,2,…,15), C_{rl} is the corresponding statistic for the "standard" state or metropolitan area with the lowest prevalence (i.e., DC or San-Francisco for Long COVID), and I is the number of states (51) or metropolitan areas (15) being compared.

While RMSD is a measure of absolute health disparity, the coefficient of variation (CV) of the

Table 2: Unadjusted and Adjusted Weighted Prevalence (%), Odds of Severe COVID Symptoms, and Health Disparity Indices in 50 States and the District of Columbia, US Adults Aged ≥18 Years: The Household Pulse Survey, Weeks 46 to 50, June 1 - October 17, 2022 (N=108,064)

	Unadjusted Prevalence		Unadj. Odds Ratio and 95% Confidence Interval			Adjusted Odds Ratio and 95% Confidence Interval			Adjusted Prevalence	
	%	SE	OR	Lower	Upper	AOR	Lower	Upper	%	SE
United States	13.76	0.22								
Alaska	11.25	1.23	1.68	1.14	2.47	1.48	1.00	2.19	11.58	1.25
Alabama	19.35	1.62	3.18	2.21	4.57	2.52	1.74	3.65	18.04	1.50
Arkansas	15.87	1.40	2.50	1.74	3.60	2.03	1.41	2.94	15.17	1.32
Arizona	14.63	1.19	2.27	1.59	3.24	1.83	1.27	2.62	13.89	1.12
California	12.41	0.79	1.88	1.35	2.62	1.50	1.07	2.11	11.73	0.76
Colorado	14.18	1.20	2.19	1.53	3.13	2.07	1.44	2.98	15.42	1.25
Connecticut	13.67	1.20	2.10	1.46	3.01	1.96	1.35	2.84	14.73	1.30
District of Columbia	9.81	2.24	1.44	0.81	2.58	1.44	0.78	2.63	11.31	2.60
Delaware	12.33	1.49	1.86	1.24	2.79	1.63	1.08	2.47	12.63	1.53
Florida	12.68	0.91	1.92	1.37	2.71	1.54	1.08	2.18	12.00	0.88
Georgia	15.33	1.20	2.40	1.69	3.41	1.98	1.38	2.84	14.85	1.17
Hawaii	14.22	2.03	2.20	1.41	3.43	1.82	1.16	2.87	13.87	1.95
Iowa	13.96	1.29	2.15	1.49	3.11	2.02	1.39	2.94	15.12	1.36
Idaho	14.13	1.12	2.18	1.53	3.10	1.97	1.38	2.82	14.78	1.16
Illinois	12.42	1.05	1.88	1.32	2.68	1.68	1.17	2.40	12.91	1.07
Indiana	14.32	1.14	2.21	1.56	3.15	1.98	1.38	2.83	14.83	1.17
Kansas	11.37	0.92	1.70	1.20	2.41	1.57	1.10	2.23	12.19	0.96
Kentucky	16.38	1.61	2.60	1.78	3.79	2.27	1.54	3.35	16.61	1.63
Louisiana	15.70	1.40	2.47	1.71	3.56	1.91	1.31	2.79	14.43	1.34
Massachusetts	9.98	0.99	1.47	1.01	2.13	1.39	0.96	2.03	11.03	1.07
Maryland	12.72	1.07	1.93	1.35	2.76	1.76	1.22	2.52	13.43	1.12
Maine	10.94	1.46	1.63	1.07	2.48	1.52	0.99	2.34	11.91	1.57
Michigan	12.56	0.95	1.90	1.35	2.69	1.74	1.23	2.48	13.34	1.00
Minnesota	11.84	1.01	1.78	1.25	2.54	1.77	1.23	2.55	13.54	1.16
Missouri	13.38	1.20	2.05	1.42	2.94	1.84	1.27	2.66	13.97	1.22
Mississippi	19.89	1.79	3.29	2.27	4.78	2.49	1.71	3.64	17.88	1.61
Montana	15.14	1.70	2.36	1.59	3.52	2.14	1.44	3.18	15.81	1.66
North Carolina	13.88	1.18	2.14	1.49	3.05	1.79	1.24	2.59	13.66	1.18
North Dakota	15.71	1.64	2.47	1.68	3.64	2.31	1.57	3.42	16.86	1.68
Nebraska	13.05	1.12	1.99	1.39	2.84	1.84	1.28	2.65	13.99	1.16
New Hampshire	11.21	1.13	1.67	1.15	2.43	1.61	1.10	2.35	12.46	1.22
New Jersey	13.22	1.21	2.02	1.40	2.91	1.80	1.24	2.61	13.69	1.24
New Mexico	16.21	1.34	2.56	1.79	3.67	1.91	1.32	2.75	14.39	1.21
Nevada	15.36	1.38	2.41	1.67	3.47	1.89	1.30	2.74	14.28	1.28
New York	13.77	1.31	2.12	1.46	3.07	1.80	1.23	2.64	13.74	1.32
Ohio	14.10	1.34	2.18	1.50	3.15	1.93	1.32	2.81	14.54	1.36

(Contd...)

Table 2: *(Continued)*

	Unadjusted Prevalence		Unadj. Odds Ratio and 95% Confidence Interval			Adjusted Odds Ratio and 95% Confidence Interval			Adjusted Prevalence	
	%	SE	OR	Lower	Upper	AOR	Lower	Upper	%	SE
Oklahoma	14.84	1.17	2.31	1.62	3.28	1.93	1.35	2.76	14.54	1.13
Oregon	12.37	0.98	1.87	1.32	2.65	1.68	1.18	2.40	12.96	1.00
Pennsylvania	13.80	1.26	2.12	1.47	3.06	1.92	1.33	2.78	14.47	1.27
Rhode Island	12.39	1.90	1.87	1.19	2.96	1.64	1.02	2.64	12.68	1.99
South Carolina	14.86	1.21	2.31	1.62	3.30	1.88	1.31	2.70	14.22	1.16
South Dakota	14.98	1.92	2.34	1.53	3.56	2.20	1.43	3.38	16.18	2.03
Tennessee	14.47	1.27	2.24	1.56	3.22	1.94	1.35	2.78	14.58	1.21
Texas	16.46	1.02	2.61	1.87	3.65	2.07	1.48	2.91	15.42	0.94
Utah	14.26	1.01	2.20	1.57	3.10	2.14	1.51	3.04	15.84	1.09
Virginia	14.34	1.21	2.22	1.55	3.17	2.05	1.43	2.96	15.29	1.27
Vermont	7.01	1.00	1.00	Reference		1.00	Reference		8.22	1.16
Washington	11.80	0.84	1.77	1.26	2.49	1.63	1.15	2.30	12.61	0.89
Wisconsin	10.38	0.96	1.53	1.07	2.21	1.42	0.98	2.05	11.19	1.03
West Virginia	16.16	1.68	2.55	1.74	3.76	2.16	1.46	3.21	15.96	1.64
Wyoming	14.85	1.46	2.31	1.59	3.37	2.04	1.39	2.99	15.22	1.47
Health disparity indices										
CV	16.50								13.06	
RMSD	7.08								6.06	
CV(RMSD)	100.98								73.68	

SE= standard error; OR=odds ratio; AOR=adjusted odds ratio; RMSD=root-mean-square-deviation; CV=coefficient of variation. Chi-square statistics for testing the overall association between state and prevalence of severe COVID symptoms were statistically significant at p<0.01. Odds ratios (ORs), estimated by logistic model, were unadjusted for the effects of other covariates. Adjusted odds ratios (AORs) were estimated by logistic regression model that controlled for age, race/ethnicity, gender, LGBT status, marital status, region of residence, education, household income, housing tenure, and health insurance status.

RMSD provides an estimate of relative disparity and is given by

$$CV(RMSD) = \left(\frac{RMSD}{C_{rl}}\right) \times 100, \qquad C_{rl} > 0$$

3. Results

3.1. State and Metropolitan Area Disparities in Long COVID Prevalence

During June–October 2022, an estimated 35.4 million or 32.2% of US adults aged ≥18 years with COVID-19 infection reported experiencing Long COVID symptoms (Table 1). This amounts to 14.4% (or 1 in 7) of all US adults developing Long COVID at some point (data not shown). Among those who reported experiencing Long COVID, 18.2 million or 51.6% reported having Long COVID symptoms currently (data not shown).

The prevalence of Long COVID ranged from a low of 24.0% in DC, 25.4% in Hawaii to a high of 39.2% in Alabama, 39.9% in Wyoming, and 43.6% in West Virginia. Adjusted for individual-level covariates, adults with COVID-19 diagnosis in Alabama, Wyoming, and West Virginia had 48-178% higher adjusted odds of developing Long COVID than their counterparts in DC (Table 1). State maps on unadjusted and adjusted prevalence show higher rates of Long COVID in the Southeast, Southwest, and Northern Plains states and lower rates of Long COVID in states along the East and West coasts of the United States (Figure 3).

Large disparities in Long COVID prevalence among the 15 largest metropolitan areas ranged from 21.9% in San Francisco to 38.0% in Riverside, California (Figure 1). Adults with COVID-19 diagnosis in Atlanta, Phoenix, Chicago, Riverside, and Detroit

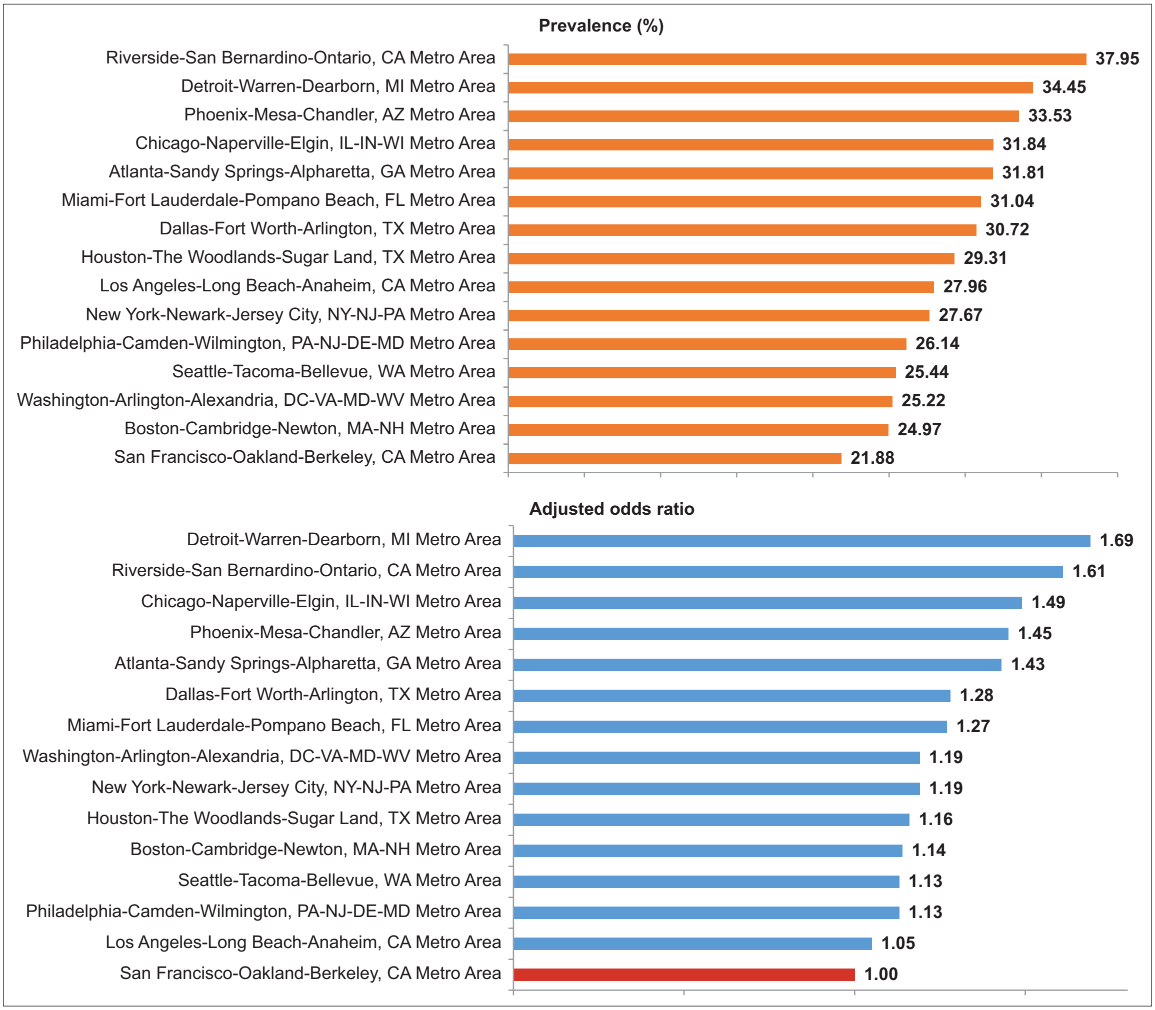

Figure 1: Prevalence[1] and Adjusted[2] Odds Ratios for Long COVID among Adults Aged ≥18 Years in the 15 Largest Metropolitan Statistical Areas (MSAs), United States, June-October 2022 (N=33,253)
[1]Long COVID prevalence rates for all MSAs except Boston, Philadelphia, Seattle, and DC MSAs were significantly higher than the rate for the San Francisco MSA at $p<0.05$. [2]Adjusted by logistic regression for age, race/ethnicity, gender, LGBT status, marital status, education, household income, housing tenure, and insurance status. The adjusted odds ratio for Atlanta, Chicago, Detroit, Phoenix, and Riverside MSAs were significantly higher than the San Francisco MSA at $p<0.05$.
Source: Data derived from June-October 2022 Household Pulse Survey

metropolitan areas had 43-69% higher adjusted odds of developing Long COVID than their counterparts in the San Francisco Metropolitan Area (Figure 1).

Health disparity indices in Table 1 summarize geographic disparities in Long COVID and provide an assessment of the extent to which the observed geographic disparities can be attributed to state or metropolitan area differences in individual-level socioeconomic, demographic, and health insurance characteristics. The relative summary index of state disparity, CV(RMSD), decreased from 41.0% for the crude prevalence to 27.2% for the adjusted prevalence, suggesting that the adjustment for the individual-level sociodemographic and healthcare factors accounted for 34% of the state disparity in

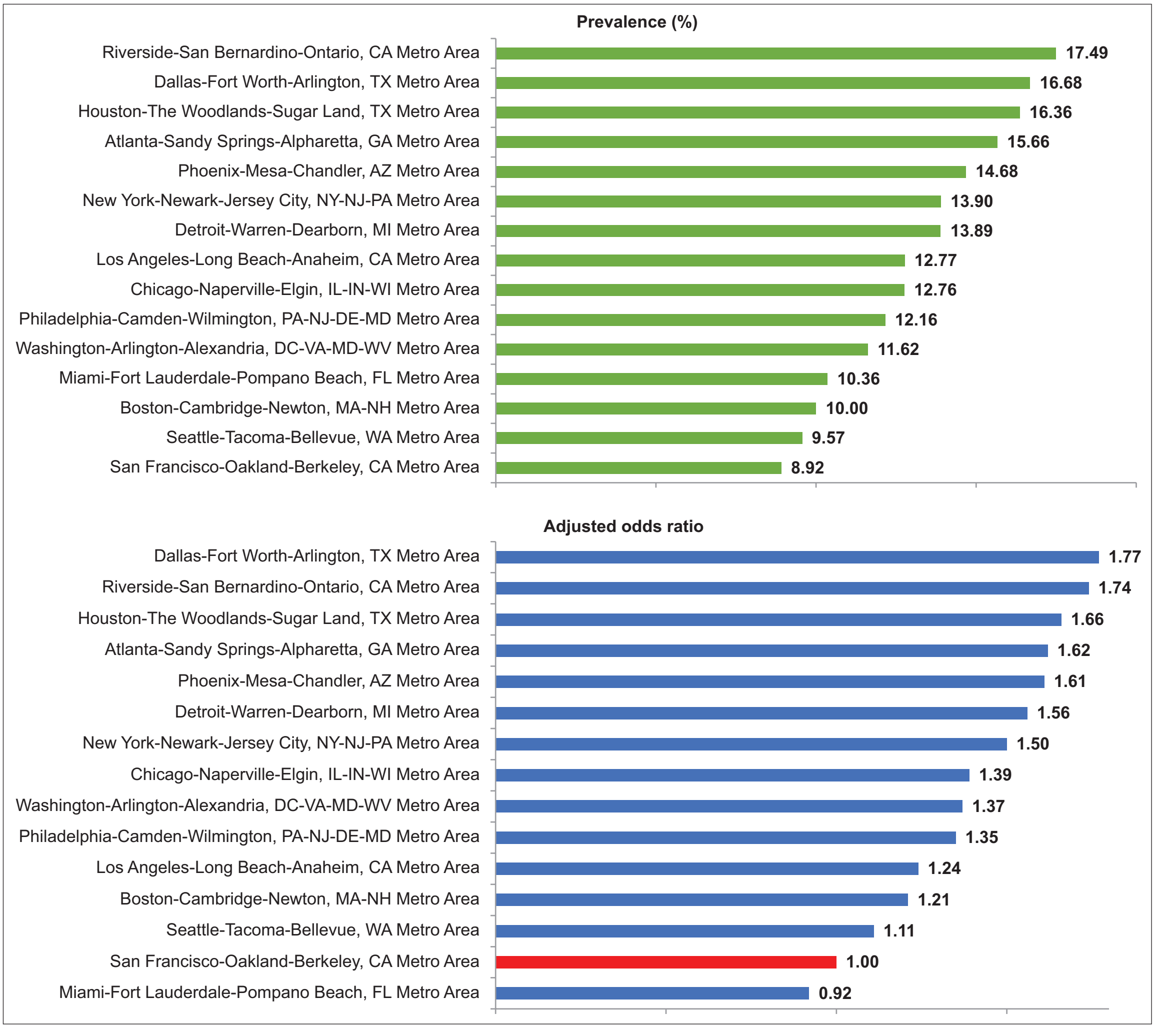

Figure 2: Prevalence[1] and Adjusted[2] Odds Ratios for Severe COVID Symptoms among Adults Aged ≥18 Years in the 15 Largest Metropolitan Statistical Areas (MSAs), United States, June-October 2022 (N=33,202)
Prevalence rates for severe COVID symptoms for all MSAs except Boston, Philadelphia, Seattle, and DC MSAs were significantly higher than the rate for the San Francisco MSA at p<0.05. Adjusted by logistic regression for age, race/ethnicity, gender, LGBT status, marital status, education, household income, housing tenure, and insurance status. Adjusted odds ratios for Atlanta, Chicago, Detroit, Phoenix, and Riverside MSA were significantly higher than the San Francisco MSA at p<0.05.
Source: Data derived from June-October 2022 Household Pulse Survey

Long COVID. Adjustment for sociodemographic factors accounted for 45% of the metropolitan-area disparity in Long COVID (data not shown). The simple index of CV indicates a 21% reduction in state disparity (13.1% vs.10.4%) and a 29% metropolitan-area disparity in Long COVID after covariate adjustment.

3.2. State and Metropolitan Area Disparities in COVID-19 Disease Severity

An estimated 15.2 million (13.8%) US adults aged ≥18 with COVID infection reported experiencing severe COVID symptoms from June to October 2022 (Table 2). The prevalence of severe COVID symptoms ranged from 19.9% in Mississippi and

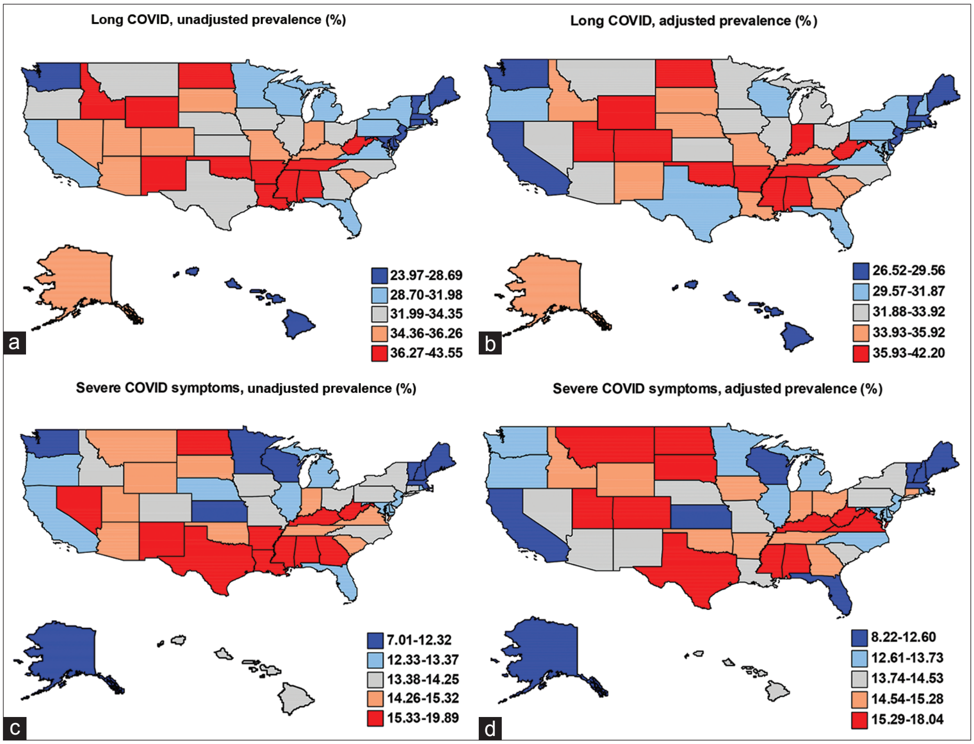

Figure 3: (a-d) State Differences in the Prevalence of Long COVID and Severe COVID Symptoms (%) among Adults Aged ≥18 Years During the COVID-19 Pandemic, United States, June - October 2022
Adjusted prevalence estimates for Long COVID and severe COVID symptoms were derived by logistic regression models that controlled for age, race/ethnicity, gender, LGBT status, marital status, education, household income, housing tenure, and health insurance status

19.4% in Alabama to 9.8% in DC and 7.0% in Vermont. Adults with COVID-19 diagnosis in Alabama, Arkansas, Colorado, Iowa, Kentucky, Mississippi, Montana, North Dakota, South Dakota, Texas, Utah, Virginia, Wyoming, and West Virginia had 2.0-2.5 times higher adjusted odds of experiencing severe COVID symptoms than their counterparts in Vermont. State maps on unadjusted and adjusted prevalence show higher rates of severe COVID symptoms in the Southeast, Southwest, and Northern Plains states and lower rates of severe COVID symptoms in states along the East and West coasts of the US (Figure 3). The correlation coefficient between state rates of Long COVID and severe COVID symptoms was 0.71.

Disparities in the prevalence of severe COVID symptoms among the 15 metropolitan areas were pronounced, with the prevalence ranging from 8.9% in San Francisco to 17.5% in Riverside, California (Figure 2). Adults with COVID-19 diagnosis in New York, Detroit, Phoenix, Atlanta, Houston, Riverside, and Dallas metropolitan areas had 50-77% higher adjusted odds of experiencing severe COVID symptoms than their counterparts in the San Francisco Metropolitan Area (Figure 2).

State disparities in severe COVID symptoms, as measured by CV(RMSD), were reduced from 101.0% for the unadjusted prevalence to 73.7% for the adjusted prevalence, indicating a 27% reduction in state disparity after the adjustment for the individual-level covariates (Table 2). Individual-level sociodemographic factors explained 13% of the metropolitan-area disparity in severe COVID symptoms (data not shown).

4. Discussion

In this study, using recent national data, we have analyzed state and metropolitan area disparities in the prevalence of Long COVID and disease severity among COVID patients/survivors in the US. We found marked geographic disparities, with COVID survivors in the Southeast, Southwest, and Northern Plains states being at substantially higher risks of developing Long COVID and severe COVID symptoms. This study is the first to document state and metropolitan area disparities in Long COVID and disease severity among COVID survivors during the ongoing pandemic and to explore whether individual-level socioeconomic, demographic, and health insurance factors explain these geographic disparities. Additionally, our study makes a unique contribution to COVID-19 research by identifying specific geographic areas in which American adults face increased risks of post-COVID conditions and severe COVID symptoms and who are, therefore, in need of greater healthcare access and preventive, treatment, and social services.[14,15,26] Equitable access to and utilization of healthcare and other services among patients afflicted with Long COVID and related conditions is critical to reducing geographic inequities in COVID-related health outcomes.

Our study findings on geographic disparities in Long COVID and severe COVID symptoms are generally consistent with those that show significant geographic disparities in COVID-19 cases and mortality and mortality from several leading causes of death, chronic health conditions, and behavioral risk factors.[9,23,30,35,36] Data from the 2021 Behavioral Risk Factor Surveillance System (BRFSS) show higher rates of fair/poor overall health, chronic conditions such as heart disease, hypertension, diabetes, kidney disease, and COPD, and behavioral risk factors such as smoking, physical inactivity, and obesity in the Southeastern and Southwestern parts of the US.[23] Consistent with geographic patterns in Long COVID or disease severity, Southeastern and Southwestern states have higher rates of COVID-19 diagnoses and mortality and lower rates in states along the East and West coasts of the US.[9,35]

4.1. Limitations

This study has some limitations. HPS does not collect information on many factors that could help explain geographic disparities in Long COVID and disease severity among COVID patients/survivors, including social and physical isolation, lack of social support or connectedness, loss of self-identity and sense of control, unhealthy diet, lack of physical inactivity, smoking, alcohol and other substance use, lack of or limited access to care, and comorbidities.[22] Although comorbidities such as hypertension, smoking, diabetes, obesity and other pre-existing conditions are important risk factors for COVID-19 infection, Long COVID, and disease severity, they may not fully explain geographic disparities in Long COVID shown here.[18,24,37] In fact, Long COVID can develop among people who have had no or mild symptoms, although people with more severe COVID symptoms are at the greatest risk of developing Long COVID and long-term impairments.[18,24]

Second, data on specific clinically diagnosed COVID symptoms were not available in HPS. Moreover, the self-reported cases of Long COVID are probably underestimated as has been the case with official estimates of COVID-19 infections, hospitalizations, and deaths.[38] Many of the COVID patients whose symptoms have persisted for longer than three months since or sometime after the initial COVID-19 diagnosis may not be aware that the painful symptoms or health conditions they currently experience might actually be due to Long COVID. However, self-reported nature of the HPS data on Long COVID symptoms and lack of clinical assessment in some cases might have erroneously been attributed to Long COVID, resulting in an overestimation of the prevalence.[39]

Third, due to confidentiality concerns, public use HPS files do not provide geographic data below the state level (e.g., county level).[12,28,29] Because of significant heterogeneity in socioeconomic, health status, and health care characteristics across US counties, actual geographic disparities in the prevalence of Long COVID and severe COVID symptoms, as captured by state-level differences, are likely underestimated.[9,35]

Fourth, our study did not analyze geographic patterns in Long COVID and disease severity separately for men and women and by race/ethnicity. We found a 45% higher risk of Long COVID among women than men and 47-75% higher risk of Long COVID among Hispanics, Blacks, and non-Hispanic Whites than Asians (data not shown). Future studies might benefit from examining whether geographic patterns differ by gender and among racial/ethnic minorities.

Fifth, the respondents in HSP are more likely to be women and non-Hispanic Whites and have higher education, compared with the American Community Survey.[40] This might have resulted in an underestimate of the magnitude of disparities in COVID-related outcomes. However, we addressed disproportionate sampling of demographic characteristics by using survey weights, which rakes the demographics of the interviewed persons to education attainment/sex/age distributions and ethnicity/race/sex/age population distributions.[29]

5. Conclusion and Implications for Translation

Based on our analysis of recent national data on 108,064 COVID survivors aged ≥18 years, we found significant disparities in Long COVID and severe COVID symptoms across state and metropolitan areas in the US, even after accounting for a range of patient-level socioeconomic, demographic, and health care factors. These data should contribute significantly to understanding the underlying social determinants, causes, and epidemiology of disparities in Long COVID and could be immensely useful in developing state- and community-based policies, programs, and strategies for providing health care, treatment, and support services to those afflicted with Long COVID and associated health conditions.

Compliance with Ethical Standards

Conflicts of Interest: *The authors declare that they have no conflict of interest.* ***Financial Disclosure****: None to report.* ***Funding/Support****: None.* ***Ethical approval:*** *No IRB approval was required for this study, which is based on the secondary analysis of a public-use federal database.* ***Acknowledgments:*** *None.* ***Disclaimer:*** *The views expressed are the authors' and not necessarily those of their institutions.*

Key Messages

- ► During June–October 2022, an estimated 35.4 million or 32.2% of US adults aged ≥18 years with COVID-19 infection reported developing Long COVID. During this period, of all US adults, 1 in 7 developed Long COVID at some point. In states such as West Virginia, Wyoming, and Alabama, almost 1 in 5 adults reported developing Long COVID.
- ► Approximately 15.2 million or 13.8% of US adults aged ≥18 with COVID infection reported experiencing severe COVID symptoms.
- ► Prevalence of Long COVID ranged from a low of 24.0% in DC and 25.4% in Hawaii to a high of 39.2% in Alabama, 39.9% in Wyoming, and 43.6% in West Virginia. Among the largest metropolitan areas, Riverside, California had the highest prevalence and San Francisco, California the lowest prevalence of Long COVID and severe COVID symptoms.
- ► COVID patients/survivors in the Southeast, Southwest, and Northern Plains states in the US had a substantially higher risk of developing Long COVID and severe COVID symptoms.
- ► Equitable access to care among those with Long COVID is critical to reducing geographical inequities in COVID-related health outcomes.

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