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ORIGINAL ARTICLE | LONG COVID

Disparities in Prevalence of COVID-19, Long COVID, Disease Severity, and Mental Health Outcomes among US Adults by Industrial Sector of Employment, September-November 2022

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ABSTRACT

Background: The coronavirus disease (COVID-19) pandemic has had a major adverse impact on people's health and well-being in the United States (US) and globally. Although inequalities in COVID-19 prevalence and to a lesser extent in Long COVID and related mental health impact among US adults have been documented, disparities in COVID-related outcomes by industrial sector of employment, an important social determinant, have not been studied. Using the latest nationally representative data, we examine disparities in COVID-19, Long COVID, and associated mental health impact among US adults aged ≥18 years by industrial sector.

Methods: Using three consecutive rounds of the US Census Bureau's Household Pulse Survey from September 14 to November 14, 2022 (N=148,813), disparities in COVID-related outcomes by industrial sector were modeled by multivariable logistic regression after controlling for race/ethnicity, socioeconomic status, health insurance, and other demographic characteristics.

Results: During September–November 2022, an estimated 117 million or 48.7% of US adults reported having been diagnosed with COVID-19; 34.3 million or 29.4% of COVID patients reported developing Long COVID; 14.7 million or 12.6% of COVID patients reported experiencing severe COVID symptoms; 10.7% of COVID patients reported serious depression, and 17.8% reported serious anxiety. Adjusted for covariates, workers in wholesale trade, finance and insurance, educational services, healthcare, social assistance, and accommodation and food services had 30-39% higher odds of being diagnosed with COVID-19 than workers in the agricultural sector. Workers in social assistance, real estate, utilities, construction, and healthcare sectors had 48-102% higher adjusted odds of developing Long COVID than workers in wholesale trade.

Conclusion and Implications for Translation: Marked disparities in COVID-related outcomes existed, with workers in employment industries such as healthcare, social assistance, real estate, arts and entertainment, and accommodation and food services being at increased risk of COVID-19 diagnosis, Long COVID, severe COVID symptoms, serious depression, and anxiety. Equitable access to social services and

healthcare, including mental and behavioral health services, among workers afflicted with these conditions is critical to reducing inequities in COVID-related health outcomes.

Keywords: • COVID-19 • Pandemic • Long COVID • Disease Severity • Depression • Anxiety • Disparities • Industry • Social Determinants

1. Introduction

The coronavirus disease (COVID-19) pandemic has had a devastating impact on people's health and well-being in the United States and globally over the past two years, leading to widespread social and economic disruptions, social isolation, mental health problems, reduced access to healthcare and welfare services, excess premature mortality, and declines in life expectancy.[1–9] The US has been greatly affected by the pandemic, with 99.9 million confirmed COVID-19 cases and 1.09 million deaths as of December 18, 2022,[8] in comparison to 647,972,911 confirmed cases and 6,642,832 deaths globally.[2]

While the disease burden associated with COVID-19 cases, deaths, and hospitalizations has been considerable, a derivative condition called "Long COVID" has afflicted nearly 36 million COVID-19 survivors in the US, causing considerable suffering and disabilities.[10–12] 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.[11-14] 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.[14–16] A newly released study attributed 3,544 US deaths to Long COVID between January 2020 and July 2022.[17]

Besides the health impact, Long COVID has had a substantial impact on the US economy and labor markets. A recent study by the Brookings Institution estimates that 4 million Americans are likely out of work today due to Long COVID, costing $170 billion to $230 billion annually in lost wages alone.[18] Another US study has attributed increased medical spending and reduced labor supply to Long COVID, resulting in significant income loss, a shortage of workers, and a surge in inflation.[19]

Although inequalities in COVID-19 prevalence and to a lesser extent in Long COVID and related mental health impact among US adults have been documented by several sociodemographic factors such as age, gender, race/ethnicity, education, household income, job loss, and healthcare access,[6,9,10,20] disparities in COVID-related outcomes by industrial sector of employment, an important social determinant, have not yet been studied. Inequalities in health and COVID-related outcomes by industry may reflect differences among workers in various industries in socioeconomic conditions, health-risk behaviors, work-related stress, psychological distress, environmental risk exposures including injuries and occupational hazards, 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.[9,21–25]

Such analyses of disparities are urgently needed to ensure more equitable access to healthcare, treatment, and social services and prevent disparities in COVID-related health outcomes from widening further.[5,9,11–13,20,21,26] To address the existing gaps in research, we use a large nationally representative survey to examine disparities in COVID-19, Long COVID, disease severity, and associated health impact among US adults aged ≥18 years by industrial sector of employment during the ongoing coronavirus pandemic.

2. Methods

2.1. Data

We used pooled data from three consecutive samples of the US Census Bureau's Household Pulse Survey (HPS) conducted during September, October, and November 2022. The three independent HPS samples that included information on COVID-19 diagnosis, long COVID, and industry of employment among adults aged ≥18 years were: Week 49, September 14–28; Week 50, October 5–17; and Week 51, November 2–14, 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 survey was developed as a rapid response survey in order to track the social and economic impacts of the COVID-19 pandemic on American households on a weekly or bi-weekly basis in partnership with several federal statistical agencies.[28,29] Information collected in the survey is based on self-reports by respondents aged 18 years and older. The HPS uses a systematic sample design and is representative of the civilian non-institutionalized population of the US. Substantive and methodological details of the survey are available elsewhere.[27-29]

2.2. Measurement of Five Outcome Variables: COVID-19 Diagnosis, Long COVID, COVID Disease Severity, Serious Depression, and Serious Anxiety

We used five COVID-related binary outcome variables. The first outcome variable, the COVID-19 diagnosis, was derived from the question: "*Have you ever tested (using a rapid point-of-care test, self-test, or laboratory test) positive for COVID-19 or been told by a doctor or other healthcare provider that you have or had COVID-19?*" [28] Adults responding "yes" were defined as having been diagnosed with COVID-19 and those with "no" responses were considered as not having the disease diagnosis.

The second 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 of thinking, concentrating, forgetfulness, or memory problems (sometimes referred to as "brain fog," difficulty of 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" responses were considered not to have Long COVID.

The third 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 fourth outcome variable, depression, was derived from the question *"Over the last 7 days, how often have you been bothered by… feeling down, depressed, or hopeless? Would you say not at all, several days, more than half the days, or nearly every day?"* Respondents who reported feeling down, depressed, or hopeless nearly every day of the past week were defined as having serious depression.

The fifth outcome variable, anxiety, was derived from the question *"Over the last 7 days, how often have you been bothered by the following problems… feeling nervous, anxious, or on edge? Would you say not at all, several days, more than half the days, or nearly every day?"* Respondents who reported feeling nervous, anxious, or on edge nearly every day of the past week were defined as having serious anxiety.

The pooled sample size from September-December 2022 HPS was 148,813 adults aged ≥18 years for whom information on the outcome variables and industry was available.[27]

2.3. Measurement of Industrial Sector and Covariates

The independent variable of interest was the respondent's business or industry of employment in

the past seven days at the time of the survey.[27] The industrial sector of employment variable consisted of 23 categories, including agriculture, mining, utilities, construction, manufacturing, wholesale trade, retail trade, transportation and warehousing, information technology, finance and insurance, real estate, professional, scientific, and technical services, management of companies, administrative and support services, waste management, educational services, healthcare, social assistance, arts and entertainment, accommodation and food services, public administration, other services, and a category for non-employed individuals, as shown in Tables 1 and 2.

Based on previous research and the social determinants of health framework, we selected the following covariates for the five outcome variables: age, race/ethnicity, gender, LGBT status, marital status, region of residence, educational attainment, household income, housing tenure, and health insurance status.[6,9,10,21,27,30] The covariates were measured as shown in Tables 1 and 2.

2.4. Statistical Methods

Multivariable logistic regression was used to model disparities in COVID-related outcomes by industrial sector after controlling for socioeconomic, demographic, and health characteristics. The chi-square statistic was used to test the overall association between each covariate and vaccination prevalence, whereas the two-sample t-test was used to test the difference in prevalence between any two groups or 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 five outcome variables were derived by the logistic model at the mean values of the covariates.

3. Results

3.1. Disparities in COVID-19 Prevalence by Industry

During September–November 2022, an estimated 117 million or 48.7% of US adults aged ≥18 years reported having been diagnosed with COVID-19 (Table 1). COVID-19 prevalence ranged from 46.7% for workers in the agricultural sector to 58.0% for workers in the healthcare sector. Adjusted for covariates, compared to workers in the agricultural sector, workers in wholesale trade, finance and insurance, educational services, healthcare, social assistance, and accommodation and food services had 30-39% higher odds of being diagnosed with COVID-19 (Table 1).

3.2. Disparities in Long COVID Prevalence by Industry of Employment

During September–November 2022, an estimated 34.3 million or 29.4% of US adults aged ≥18 years with COVID-19 infection reported experiencing Long COVID symptoms (Table 1). This amounts to 14.3% (or 1 in 7) of all US adults developing Long COVID at some point (data not shown in Tables). Among those who reported experiencing Long COVID, 16.8 million or 49.2% reported having Long COVID symptoms currently (data not shown in Tables).

Long COVID prevalence ranged from 20.4% for workers in the wholesale trade sector to 38.5% for workers in the social assistance sector. Adjusted for covariates, workers in social assistance, real estate, utilities, construction, and healthcare sectors had, respectively, 102%, 81%, 67%, 66%, and 48% higher odds of developing Long COVID than workers in wholesale trade (Table 1). Among those who experienced Long COVID, workers in retail trade, educational services, and healthcare industries had 58-61% higher odds of having Long COVID symptoms currently than workers in the accommodation and food services sector (data not shown in Tables).

3.3. Disparities in COVID-19 Severity by Industry of Employment

During September–November 2022, an estimated 14.7 million or 12.6% of US adults aged ≥18 years with COVID-19 infection reported experiencing severe COVID symptoms. The prevalence of severe COVID symptoms ranged from 6.8% for workers in public administration to 14.9% for workers in the social assistance sector. Adjusted for covariates, workers in retail trade, finance and insurance, real estate, professional and technical services, management

Table 1: Unadjusted and Adjusted Weighted Prevalence (%) and Odds of COVID-19 Diagnosis, Long COVID, and Disease Severity by Industry of Employment, US Adults Aged ≥ 18 Years: The Household Pulse Survey, Weeks 49 to 51, September 14 - November 14, 2022

Industry sector	Unadjusted		Unadjusted			Adjusted			Adjusted	
	Prevalence	SE	OR[1]	95% CI		OR[2]	95% CI		Prevalence[2]	SE
COVID-19 Diagnosis (N=148,813)										
All sectors	48.73	0.28								
Agriculture, Forestry, Fishing and Hunting	46.73	2.87	1.00	reference		1.00	reference		45.46	2.61
Mining, Quarrying, and Oil and Gas Extraction	54.36	3.28	1.36	0.96	1.91	1.26	0.91	1.75	51.04	3.03
Utilities	48.79	2.97	1.09	0.79	1.50	1.01	0.74	1.39	45.78	2.85
Construction	51.42	1.68	1.21	0.93	1.57	1.20	0.93	1.54	49.76	1.61
Manufacturing	50.89	1.42	1.18	0.92	1.52	1.14	0.89	1.45	48.55	1.42
Wholesale Trade	55.12	2.77	1.40	1.02	1.92	1.38	1.01	1.88	53.20	2.71
Retail Trade	50.66	1.27	1.17	0.91	1.50	1.14	0.90	1.45	48.64	1.23
Transportation and Warehousing	50.14	1.69	1.15	0.88	1.49	1.17	0.91	1.50	49.19	1.63
Information Technology	51.24	1.22	1.20	0.94	1.53	1.00	0.79	1.27	45.54	1.27
Finance and Insurance	57.54	1.23	1.54	1.21	1.98	1.30	1.02	1.65	51.68	1.27
Real Estate and Rental and Leasing	50.62	2.13	1.17	0.88	1.55	1.10	0.84	1.44	47.66	2.00
Professional, Scientific, and Technical Services	54.76	1.02	1.38	1.09	1.75	1.23	0.97	1.55	50.40	1.09
Management of Companies and Enterprises	56.57	3.24	1.48	1.05	2.09	1.31	0.93	1.86	51.99	3.36
Administrative and Support Services	55.87	2.00	1.44	1.10	1.90	1.26	0.96	1.65	51.04	2.01
Waste Management and Remediation Services	57.80	4.92	1.56	0.99	2.46	1.49	0.94	2.34	54.92	4.87
Educational Services	56.63	0.90	1.49	1.17	1.89	1.31	1.05	1.65	52.00	0.99
Healthcare	57.96	0.79	1.57	1.24	1.99	1.39	1.11	1.74	53.38	0.82
Social Assistance	56.30	2.45	1.47	1.09	1.98	1.35	1.01	1.80	52.58	2.37
Arts, Entertainment, and Recreation	55.24	1.84	1.41	1.08	1.84	1.30	1.00	1.68	51.65	1.84
Accommodation and Food Services	55.65	2.04	1.43	1.08	1.89	1.35	1.03	1.77	52.61	1.99
Public Administration	54.27	2.46	1.35	1.00	1.82	1.23	0.92	1.64	50.46	2.37
Other Services (except Public Administration)	51.82	0.98	1.23	0.97	1.56	1.18	0.94	1.48	49.37	0.97
Not employed	41.80	0.46	0.82	0.65	1.03	1.05	0.84	1.30	46.53	0.49
Long COVID (N=70,758)										
All sectors	29.36	0.35								
Agriculture, Forestry, Fishing and Hunting	27.82	3.21	1.50	0.92	2.44	1.41	0.86	2.31	28.61	3.07
Mining, Quarrying, and Oil and Gas Extraction	27.60	3.88	1.48	0.87	2.53	1.67	0.95	2.93	31.96	4.35
Utilities	30.64	4.14	1.72	1.01	2.93	1.67	1.00	2.79	31.99	3.61
Construction	29.36	2.08	1.62	1.06	2.46	1.66	1.08	2.55	31.80	2.07
Manufacturing	23.98	1.51	1.23	0.82	1.84	1.24	0.81	1.88	26.09	1.57
Wholesale Trade	20.43	3.07	1.00	reference		1.00	reference		22.39	3.26
Retail Trade	31.61	1.64	1.80	1.21	2.68	1.47	0.97	2.23	29.43	1.52
Transportation and Warehousing	24.69	1.96	1.28	0.84	1.95	1.21	0.78	1.87	25.70	1.90
Information Technology	21.68	1.33	1.08	0.72	1.61	1.43	0.94	2.16	28.81	1.59
Finance and Insurance	23.79	1.36	1.22	0.82	1.81	1.26	0.83	1.91	26.50	1.48
Real Estate and Rental and Leasing	32.64	2.81	1.89	1.21	2.95	1.81	1.15	2.86	33.71	2.69

(Contd...)

Table 1: ***(Continued)***

Industry sector	Unadjusted		Unadjusted			Adjusted			Adjusted	
	Prevalence	SE	OR[1]	95% CI		OR[2]	95% CI		Prevalence[2]	SE
Professional, Scientific, and Technical Services	23.07	1.19	1.17	0.79	1.73	1.44	0.96	2.17	29.01	1.40
Management of Companies and Enterprises	27.31	3.74	1.46	0.87	2.47	1.50	0.88	2.57	29.86	3.82
Administrative and Support Services	34.27	2.69	2.03	1.31	3.15	1.55	0.98	2.43	30.43	2.45
Waste Management and Remediation Services	29.10	6.49	1.60	0.78	3.28	1.49	0.70	3.16	29.70	6.53
Educational Services	26.83	1.00	1.43	0.97	2.10	1.34	0.90	2.00	27.64	1.07
Healthcare	31.17	0.96	1.76	1.21	2.58	1.48	1.00	2.21	29.60	0.97
Social Assistance	38.46	3.58	2.43	1.51	3.91	2.02	1.22	3.32	35.96	3.52
Arts, Entertainment, and Recreation	26.82	2.12	1.43	0.93	2.19	1.31	0.85	2.03	27.22	2.02
Accommodation and Food Services	30.81	2.46	1.73	1.12	2.68	1.31	0.84	2.06	27.24	2.19
Public Administration	24.26	2.94	1.25	0.77	2.03	1.31	0.79	2.15	27.12	3.05
Other Services (except Public Administration)	29.69	1.15	1.65	1.12	2.42	1.41	0.94	2.10	28.52	1.11
Not employed	31.72	0.68	1.81	1.24	2.63	1.56	1.06	2.31	30.58	0.68
Severe COVID Symptoms (N=70,686)										
All sectors	12.63	0.27								
Agriculture, Forestry, Fishing and Hunting	9.47	2.41	1.44	0.75	2.76	1.28	0.66	2.47	10.48	2.57
Mining, Quarrying, and Oil and Gas Extraction	11.10	2.51	1.72	0.93	3.15	1.72	0.93	3.21	13.53	2.93
Utilities	9.22	2.02	1.40	0.78	2.51	1.17	0.63	2.17	9.70	2.18
Construction	10.93	1.34	1.69	1.09	2.62	1.45	0.92	2.28	11.66	1.41
Manufacturing	10.86	1.14	1.68	1.10	2.55	1.46	0.95	2.25	11.76	1.24
Wholesale Trade	13.47	3.03	2.14	1.15	3.97	1.86	0.98	3.53	14.43	3.22
Retail Trade	13.79	1.38	2.20	1.45	3.33	1.68	1.09	2.57	13.21	1.32
Transportation and Warehousing	11.97	1.27	1.87	1.23	2.85	1.47	0.95	2.29	11.84	1.31
Information Technology	7.98	0.82	1.19	0.79	1.8	1.40	0.92	2.15	11.37	1.17
Finance and Insurance	11.41	1.15	1.77	1.17	2.68	1.83	1.19	2.79	14.20	1.39
Real Estate and Rental and Leasing	12.57	2.00	1.98	1.20	3.25	1.85	1.13	3.05	14.38	2.11
Professional, Scientific, and Technical Services	9.38	0.92	1.42	0.95	2.14	1.63	1.07	2.48	12.90	1.26
Management of Companies and Enterprises	13.63	2.73	2.17	1.22	3.85	2.05	1.13	3.72	15.63	3.07
Administrative and Support Services	12.50	1.78	1.96	1.22	3.15	1.55	0.96	2.50	12.35	1.71
Waste Management and Remediation Services	7.84	3.68	1.17	0.41	3.37	1.00	0.35	2.86	8.41	3.80
Educational Services	9.97	0.70	1.52	1.04	2.23	1.47	0.99	2.17	11.79	0.85
Healthcare	12.60	0.77	1.98	1.36	2.88	1.66	1.13	2.44	13.08	0.82
Social Assistance	14.89	2.73	2.41	1.39	4.16	1.94	1.11	3.39	14.91	2.68
Arts, Entertainment, and Recreation	11.44	1.95	1.78	1.06	2.97	1.64	0.97	2.76	12.95	2.12
Accommodation and Food Services	11.25	1.52	1.74	1.10	2.76	1.29	0.80	2.08	10.55	1.47
Public Administration	6.78	1.13	1.00	reference		1.00	reference		8.43	1.40
Other Services (except Public Administration)	11.82	0.84	1.84	1.26	2.7	1.45	0.98	2.15	11.66	0.82
Not employed	14.96	0.54	2.42	1.69	3.46	1.67	1.15	2.43	13.18	0.51

SE=standard error. OR=odds ratio; CI=confidence interval. Chi-square statistics for testing the overall association between industry and prevalence of COVID-19, Long COVID, or severe symptoms were statistically significant at $p < 0.01$.

[1]ORs estimated by logistic model were unadjusted for the effects of other covariates. [2]Adjusted by logistic regression model for age, race/ethnicity, gender, LGBT status, marital status, region of residence, education, household income, housing tenure, and health insurance status.

Table 2: Unadjusted and Adjusted Weighted Prevalence (%) and Odds of Serious Depression and Anxiety among COVID-19 Patients/Survivors by Industry of Employment, US Adults Aged ≥ 18 Years: The Household Pulse Survey, Weeks 49 to 51, September 14 - November 14, 2022

Industry sector	Unadjusted		Unadjusted			Adjusted			Adjusted	
	Prevalence	SE	OR[1]	95% CI		OR[2]	95% CI		Prevalence[2]	SE
Serious Depression (N=63,800)										
All sectors	10.66	0.27								
Agriculture, Forestry, Fishing and Hunting	11.42	2.73	2.21	1.10	4.47	2.09	1.03	4.22	10.56	2.30
Mining, Quarrying, and Oil and Gas Extraction	6.91	2.83	1.27	0.48	3.39	1.60	0.57	4.51	8.40	3.41
Utilities	5.50	1.23	1.00	reference		1.00	reference		5.52	1.26
Construction	8.79	1.32	1.66	0.94	2.91	1.60	0.89	2.88	8.40	1.24
Manufacturing	7.64	1.04	1.42	0.82	2.45	1.49	0.84	2.64	7.90	1.06
Wholesale Trade	10.48	3.23	2.01	0.89	4.56	2.14	0.87	5.29	10.80	3.50
Retail Trade	14.42	1.46	2.89	1.73	4.85	2.26	1.31	3.91	11.29	1.17
Transportation and Warehousing	10.76	1.56	2.07	1.18	3.63	1.78	0.99	3.20	9.23	1.31
Information Technology	5.78	0.66	1.05	0.63	1.77	1.37	0.79	2.39	7.36	0.86
Finance and Insurance	9.56	1.15	1.82	1.07	3.08	2.22	1.27	3.90	11.14	1.31
Real Estate and Rental and Leasing	7.32	1.35	1.36	0.74	2.48	1.71	0.91	3.23	8.91	1.59
Professional, Scientific, and Technical Services	7.16	0.92	1.32	0.77	2.26	1.79	1.02	3.15	9.26	1.16
Management of Companies and Enterprises	7.21	1.80	1.33	0.66	2.69	1.63	0.79	3.37	8.52	2.04
Administrative and Support Services	8.97	1.46	1.69	0.95	3.02	1.63	0.88	3.03	8.55	1.43
Waste Management and Remediation Services	6.89	2.72	1.27	0.49	3.28	1.03	0.39	2.70	5.69	2.19
Educational Services	7.97	0.68	1.49	0.91	2.44	1.90	1.12	3.24	9.76	0.86
Healthcare	10.48	0.73	2.01	1.24	3.27	2.17	1.29	3.65	10.92	0.77
Social Assistance	7.93	1.56	1.48	0.79	2.76	1.49	0.77	2.89	7.89	1.57
Arts, Entertainment, and Recreation	11.95	2.10	2.33	1.27	4.27	2.00	1.05	3.81	10.18	1.84
Accommodation and Food Services	14.78	1.79	2.98	1.74	5.11	1.78	1.01	3.12	9.21	1.13
Public Administration	4.67	0.87	0.84	0.46	1.53	1.09	0.58	2.05	5.98	1.09
Other Services (except Public Administration)	10.57	0.86	2.03	1.24	3.33	1.77	1.05	2.99	9.18	0.74
Not employed	12.59	0.57	2.47	1.54	3.97	2.72	1.64	4.50	13.13	0.57
Serious Anxiety (N=63,894)										
All sectors	17.83	0.31								
Agriculture, Forestry, Fishing and Hunting	18.14	2.89	1.92	1.11	3.34	1.80	1.02	3.17	16.84	2.55
Mining, Quarrying, and Oil and Gas Extraction	15.29	3.62	1.57	0.80	3.08	2.00	0.98	4.08	18.20	4.11
Utilities	10.33	1.88	1.00	reference		1.00	reference		10.41	1.89
Construction	15.00	1.52	1.53	0.96	2.43	1.59	0.98	2.58	15.27	1.53
Manufacturing	14.37	1.43	1.46	0.92	2.31	1.57	0.98	2.53	15.12	1.42
Wholesale Trade	12.21	2.33	1.21	0.67	2.16	1.32	0.71	2.46	13.10	2.54
Retail Trade	22.45	1.62	2.51	1.62	3.89	2.01	1.27	3.18	18.29	1.34
Transportation and Warehousing	17.14	1.86	1.79	1.12	2.88	1.71	1.05	2.78	16.14	1.65
Information Technology	11.42	0.97	1.12	0.72	1.74	1.43	0.90	2.27	14.03	1.17
Finance and Insurance	16.67	1.27	1.74	1.12	2.69	1.96	1.24	3.10	17.96	1.35
Real Estate and Rental and Leasing	14.22	1.79	1.44	0.88	2.35	1.67	1.00	2.80	15.85	1.94

(Contd...)

Table 2: ***(Continued)***

Industry sector	Unadjusted		Unadjusted			Adjusted			Adjusted	
	Prevalence	SE	OR[1]	95% CI		OR[2]	95% CI		Prevalence[2]	SE
Professional, Scientific, and Technical Services	14.55	1.12	1.48	0.96	2.29	1.88	1.19	2.97	17.38	1.29
Management of Companies and Enterprises	18.14	3.08	1.92	1.09	3.40	2.29	1.25	4.19	20.15	3.33
Administrative and Support Services	20.55	2.23	2.25	1.39	3.63	1.99	1.20	3.30	18.17	1.99
Waste Management and Remediation Services	19.85	5.43	2.15	0.99	4.68	1.88	0.84	4.22	17.39	4.74
Educational Services	17.04	0.98	1.78	1.17	2.72	2.01	1.29	3.13	18.27	1.06
Healthcare	18.13	0.86	1.92	1.27	2.91	1.87	1.21	2.90	17.35	0.85
Social Assistance	17.57	2.27	1.85	1.12	3.06	1.71	1.01	2.89	16.12	2.05
Arts, Entertainment, and Recreation	23.71	2.48	2.70	1.67	4.36	2.30	1.38	3.83	20.22	2.23
Accommodation and Food Services	24.60	2.32	2.83	1.77	4.52	1.77	1.08	2.88	16.58	1.69
Public Administration	15.07	3.93	1.54	0.75	3.17	1.89	0.91	3.93	17.49	4.09
Other Services (except Public Administration)	18.71	1.01	2.00	1.31	3.04	1.74	1.12	2.70	16.37	0.89
Not employed	18.53	0.61	1.97	1.31	2.96	2.27	1.48	3.48	20.02	0.65

SE=standard error. OR=odds ratio; CI=confidence interval. Chi-square statistics for testing the overall association between industry and prevalence of serious depression or anxiety were statistically significant at $p < 0.01$.

[1]ORs estimated by logistic model were unadjusted for the effects of other covariates. [2]Adjusted by logistic regression model for age, race/ethnicity, gender, LGBT status, marital status, region of residence, education, household income, housing tenure, and health insurance status.

of companies, healthcare, and social assistance sectors had 63-105% higher odds of experiencing severe COVID symptoms than workers in public administration (Table 1).

3.4. Disparities in Mental Health among COVID Patients (Survivors) by Industry

During September–November 2022, an estimated 10.7 million or 10.7% of adults with COVID infection (i.e., COVID-19 survivors) reported serious depression, and 18 million or 17.8% reported serious anxiety (Table 2). The prevalence of serious depression among COVID survivors ranged from 5.5% for workers in utilities to 14.8% for workers in the accommodation and food services sector. Adjusted for covariates, workers in agriculture, retail trade, finance and insurance, professional and technical services, educational services, healthcare, arts and entertainment, and accommodation and food services sectors had 78-126% higher odds of serious depression developing than workers in utilities (Table 2).

The prevalence of serious anxiety among COVID survivors ranged from 10.3% for workers in utilities to 24.6% for workers in accommodation and food services. Adjusted for covariates, workers in agriculture, retail trade, transportation and warehousing, finance and insurance, professional and technical services, management of companies, administrative and support services, educational services, healthcare, social assistance, arts and entertainment, and accommodation and food services sectors had 71-130% higher odds of serious depression developing than workers in utilities (Table 2).

4. Discussion

In this study, using the latest national data, we have analyzed disparities in the prevalence of COVID-19, Long COVID, and mental health impacts among COVID patients by industrial sector. We found marked disparities in COVID-related outcomes, with workers in industries such as healthcare, social assistance, real estate, arts and entertainment, and accommodation and food services being at increased risk of COVID-19 diagnosis, Long COVID, severe COVID symptoms, serious depression, and anxiety. Equitable access to care among workers afflicted with these conditions is critical to reducing inequities in COVID-related health outcomes.

Our study findings on disparities in COVID-19 outcomes are generally consistent with those

that show significant disparities in mortality, morbidity, and behavioral risk factors by industry of employment.[17,23,24,32] Data from the 2013 Behavioral Risk Factor Surveillance System (BRFSS) show a greater likelihood of poor self-rated health in agriculture, administrative/support/waste management services, accommodation and food services, transportation/warehousing, construction, and manufacturing sectors, and good health in professional/scientific/technical, finance/insurance, public administration, and education sectors.[23] Patterns in cardiovascular diseases (CVD) by industry are generally similar to those in self-rated health.[23] Workers in administrative/support/waste management services, transportation/warehousing, construction, manufacturing, utilities, wholesale trade, and arts/entertainment/recreation sectors have higher risks of CVD than those in the information, finance/insurance, and education sectors.[23] Consistent with patterns in Long COVID or disease severity, workers in healthcare and social assistance, administrative/support/waste management services, transportation/warehousing, construction, manufacturing, utilities, mining/oil/gas, arts/entertainment/recreation, and accommodation and food services sectors have higher risks of obesity than those in the professional/scientific/technical services sector.[23] Industry differences in depression among COVID-19 survivors are consistent with those observed for the general population in which workers in healthcare and social assistance, retail trade, real estate, administrative/support/waste management, education, arts/entertainment/recreation, and accommodation and food services report higher risks of depression than workers in public administration, utilities, construction, and agriculture.[23] Consistent with patterns in COVID-related outcomes in our study, an analysis of Michigan BRFSS data reported higher smoking rates for workers in accommodation and food services, healthcare and social assistance, administrative/support/waste management, arts/entertainment/recreation, construction, manufacturing, and transportation/warehousing and lower smoking rates for workers in professional/scientific/technical and education sectors.[24] Consistent with our study, a recent survey from the United Kingdom reported that people working in health or social care and service (hospitality) sectors had a notably higher prevalence of Long COVID.[33]

Although disparities in COVID-19-related outcomes among racial/ethnic and socioeconomic groups have been previously reported for the US population,[9,10,34] our study, to the best of our knowledge, is the first to have simultaneously examined disparities in COVID-19, Long COVID, disease severity, and the mental health impact of COVID-19 diagnosis by industrial sector during the ongoing pandemic. Additionally, our study makes a unique contribution to COVID-19 research by identifying specific industries in which workers face increased risks of COVID-19 infection, post-COVID conditions, severe disease symptoms, and mental health problems, and who, therefore, are in need of greater healthcare access and preventive, treatment, and social services.[12,13]

4.1. Limitations

This study has some limitations. First, response bias, especially related to health and healthcare outcomes, can be an issue when using self-reported data in a sample survey like the HPS. Second, HPS does not collect information on many factors that could help explain disparities in mental health problems and disease severity among workers with COVID-19 or Long COVID in various job sectors during the pandemic, including job insecurity, work-related stress, autonomy, control, and decision-making in the workplace, 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, and comorbidities.[21] Although comorbidities such as hypertension, smoking, diabetes, obesity, and other pre-existing conditions are important risk factors for COVID-19 infection, disease severity, and mental health problems, they may not fully explain disparities in Long COVID reported here.[16,25,35] 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.[16,25]

Third, data on specific COVID symptoms are not available in HPS. Moreover, the reported number

of COVID-19 infections reported here is probably underestimated, as many individuals with positive home-based self-test results do not report infections unless they seek care.[11]

Fourth, HPS is a cross-sectional survey; causality cannot be inferred especially for the association of industrial sector with COVID-19 infection, Long COVID, disease severity, and mental health impact. However, reverse causality is less of an issue, since employment in different industrial sectors is less likely to change during the course of the pandemic, and mental health was measured at the time of or the week preceding the survey.[21]

Fifth, the respondents in HPS are more likely to be women and non-Hispanic Whites and have higher education when compared, for example, with another major national sample survey such as the American Community Survey.[36] This might have resulted in an underestimate of the magnitude of disparities in COVID-related outcomes, especially among disadvantaged workers in certain industries. However, we addressed disproportionate sampling of demographic characteristics by using survey weights, which rake 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 the analysis of the latest national data on 148,813 US adults aged ≥18 years, we found significant disparities in COVID-19 infection, Long COVID, disease severity, and the mental health impact by industrial sector of employment, even after controlling for a range of sociodemographic and healthcare factors. These data should contribute significantly to understanding of the causes, epidemiology, and health effects of COVID and Long COVID, and could be immensely useful in developing policies and interventions for providing healthcare, treatment, and support services to those affected by the associated 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 September–November 2022, an estimated 117 million or 48.7% of US adults reported having been diagnosed with COVID-19; 34.3 million or 29.4% of COVID patients reported developing Long COVID. During this period, of all US adults, 1 in 7 developed Long COVID at some point.
- Among adults who reported experiencing Long COVID, 16.8 million or 49.2% reported having Long COVID symptoms currently.
- Approximately 15 million or 12.6% of COVID patients reported experiencing severe COVID symptoms; 10.7% of COVID patients/survivors reported serious depression and 17.8% reported serious anxiety.
- Workers in industries such as healthcare, social assistance, real estate, arts and entertainment, and accommodation and food services were at substantially increased risk of COVID-19 diagnosis, Long COVID, severe COVID symptoms, serious depression, and anxiety.
- Equitable access to care among workers afflicted with severe COVID symptoms, Long COVID, and associated conditions such as depression and anxiety is critical to reducing inequities in COVID-related health outcomes.

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