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RESEARCH ARTICLE

Burden of Selected Chronic Conditions Among Adults of Prime Working Age (25–54) by 2022 Self-Reported COVID-19 and Long COVID History Compared to 2019 Pre-Pandemic Baseline Prevalence: Behavioral Risk Factor Surveillance System

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ABSTRACT

Introduction: Prior research has observed increased risks for numerous chronic conditions among individuals with Long COVID. Chronic conditions have been associated with employment limitations and increased economic hardships. Data from the Behavioral Risk Factor Surveillance System (BRFSS) present an opportunity to examine changes by employment status in the prevalence of a range of chronic conditions between 2019 (pre-pandemic) and, in 2022, by self-reported COVID-19 or Long COVID.

Methods: We assessed the prevalence of chronic conditions in 2022 by employment status and self-reported COVID-19 and Long COVID history using data from BRFSS for adults of prime working age (25–54 years) who were employed for wages, self-employed, unemployed less than 1 year, unemployed 1 year or more, or unable to work. For each chronic condition (coronary heart disease and myocardial infarction [combined], stroke, ever and current asthma, chronic obstructive pulmonary disease, kidney disease, diabetes, and arthritis), we generated adjusted prevalence ratios (aPRs) comparing 2022 prevalence by COVID-19/Long COVID category to prevalences among respondents in that employment status before the pandemic (2019).

Results: The prevalence of both asthma and diabetes increased significantly between 2019 and 2022 among respondents in all included employment categories and COVID-19/Long COVID histories combined. Among employed respondents with Long COVID in 2022, aPRs using 2019 prevalence figures for all employed respondents as a baseline for comparison had statistically significant elevations for every chronic condition assessed.

Conclusions: The increased prevalence of a range of chronic conditions between 2019 and 2022 among adults with Long COVID may present a burden for individuals, the workplace, the healthcare system, and the economy. Additional research in a longitudinal context could better quantify these associations. Efforts to prevent, identify, and treat Long COVID can reduce this burden.

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1 | Introduction

Researchers have observed increased prevalence of numerous chronic conditions among individuals who have had Long COVID, defined as new symptoms and conditions that develop following SARS-CoV-2 infection and that are present for at least 3 months [1, 2]. Associations between chronic conditions and Long COVID are complex. Some conditions have been found to increase the risk of Long COVID [3–5]. However, SARS-CoV-2 infection itself has also been associated with increased incidence of conditions such as type 1 and type 2 diabetes [6–8], stroke [9], and cardiovascular events [10, 11], as well as exacerbation of asthma, chronic obstructive pulmonary disease (COPD), and other conditions [12–14]. Severity of COVID-19 illness has been associated with elevated risk of Long COVID in some research [5, 15], although Long COVID is also observed among those reporting asymptomatic or mildly symptomatic illness [16].

Both chronic conditions [17] and Long COVID [18–21] have been associated with employment limitations and increased economic hardships. Analysis of a survey conducted in 2022–2023 found that respondents with a history of Long COVID were at greater risk for economic instability (i.e., difficulty with household expenses and housing insecurity) than those who reported having had COVID but not Long COVID [22]. Long COVID in heads of household has been associated with increased economic hardship, even after controlling for pre-pandemic income level [23]. Moreover, respondents with Long COVID were more likely than those not experiencing Long COVID to report that their access to healthcare was constrained by cost issues [20].

To date, few studies have examined the prevalence of chronic conditions before and during the COVID-19 pandemic by COVID-19 and Long COVID history and by employment status. The Behavioral Risk Factor Surveillance System (BRFSS) provides an opportunity to assess prevalence changes for multiple chronic conditions between 2019 and 2022. We used 2019 BRFSS data to calculate pre-pandemic baseline prevalence figures for chronic conditions by employment status, and for 2022, we calculated the prevalence of chronic conditions by COVID-19/Long COVID status for respondents in each employment status category and compared these with the 2019 baseline. BRFSS also includes information on demographic characteristics (age, sex, race/ethnicity), as well as BMI and cigarette smoking, found in previous literature to be associated with increased prevalence of COVID-19, severity of COVID-19, prevalence of Long COVID, or prevalence of chronic conditions [3, 4, 24–26] enabling adjustment for these characteristics in the analyses. Such assessment can provide useful information about associations between COVID-19 and Long COVID and changes in the burden of chronic disease among workers and those potentially seeking employment.

2 | Methods

2.1 | Data Source

Administered annually, BRFSS is a state-based, national survey of noninstitutionalized US adults aged 18 years and older. The survey is conducted by all states, the District of Columbia, and select territories (henceforth, jurisdictions). Random-digit dialed landline and cellular telephone calls are used to collect self-reported information about demographics, healthcare access, health-related risk behaviors, and diagnosed chronic health conditions. Median BRFSS response rates across jurisdictions were 53.3% for landline and 45.9% for cellphone in 2019 and 46.3% for landline and 44.7% for cellphone in 2022. Overall and jurisdiction-level response are found at https://www.cdc.gov/brfss/data_documentation/index.htm. The US Virgin Islands (USVI) and New Jersey were excluded from these analyses because the USVI did not participate in 2019 and New Jersey was unable to collect enough data in 2019 to meet requirements for inclusion in the aggregated, national publicly available data set. BRFSS survey information was collected under OMB control number 0920-1061. This activity was reviewed and approved by the CDC as exempt human subjects research. (per 45 C.F.R. part 46.104).

2.2 | Inclusion Criteria

The BRFSS core survey includes a question about employment: "Are you currently employed for wages, self-employed, out of work for 1 year or more, out of work for less than 1 year, a student, a homemaker, retired, or unable to work?" Only one employment category is recorded per respondent. Respondents indicating they were currently employed for wages (henceforth, "employed respondents"), self-employed, out of work for less than a year ("short-term unemployed"), out of work 1 year or more ("long-term unemployed") or unable to work were included in the study population. Retirees, students, and homemakers, for whom BRFSS does not further ascertain employment status, as well as those who did not respond to the employment question, were excluded. We restricted our study population to adults of prime working age (25–54 years), as this group has the highest prevalence of labor market participation [27].

2.3 | COVID-19 and Long COVID History

Questions about COVID-19 and Long COVID history were newly introduced in the 2022 BRFSS survey. The COVID-19 question was "Has a doctor, nurse, or other health professional ever told you that you tested positive for COVID 19?" Respondents who said "no" were categorized as "no COVID-19." Participants who said "yes" or responded to the question by volunteering that they had tested positive using a home test without a health professional were considered to have a history of COVID-19. Respondents with a history of COVID-19 were further asked, "Did you have any symptoms lasting 3 months or longer that you did not have prior to having coronavirus or COVID-19?" Those who said "no" were classified as "COVID-19, no Long COVID" and those who answered affirmatively as "COVID-19 and Long COVID." For brevity, we refer to these mutually exclusive groups as "no COVID-19," "COVID-19, no Long COVID," and "Long COVID." Respondents who responded "don't know/not sure" or refused to answer the question about testing positive for COVID-19 were excluded from the analyses involving COVID-19 and Long COVID. Those

said "don't know/not sure" or refused to answer the "Long COVID" questions were retained for COVID-19, no Long COVID analyses but not for analyses of Long COVID.

2.4 | Chronic Conditions

The core BRFSS survey includes a number of questions about conditions diagnosed by a healthcare practitioner: coronary heart disease/angina, myocardial infarction, stroke, diabetes (except gestational), chronic kidney disease, ever asthma, current asthma, chronic obstructive pulmonary disease, and arthritis. In place of individual responses for coronary heart disease/angina and myocardial infarction, we used the combined coronary heart disease and myocardial infarction variable constructed by BRFSS (henceforth, "MICHD") which generates a positive answer for respondents previously diagnosed with at least one of these conditions and a negative answer for those diagnosed with neither. Missingness of chronic conditions ranged from 0.2% for diabetes in 2019 to 0.8% for current asthma in 2022.

2.5 | Statistical Analyses

We used 2019 BRFSS data to calculate pre-pandemic baseline prevalence of chronic conditions by employment status. For 2022, we calculated prevalence of chronic conditions by COVID-19/Long COVID status for respondents in each employment status category.

The BRFSS program provides data weights based on state demographic distributions. To incorporate respondents' sampling weights and account for the complex survey design, we used SAS version 9.4 (SAS Institute Inc.) and SAS-callable SUDAAN version 11.0.1 (RTI International, Research Triangle Park) for data analysis. We then aggregated the results to obtain national estimates. We used the SURVEYFREQ procedure to estimate population counts and weighted, but unadjusted, prevalence figures (95% confidence intervals [CI]) for each chronic condition.

Next, to estimate the adjusted prevalence for each year-employment status-COVID-19/Long COVID category, we used PROC RLOGIST [28] to perform logistic regression, generating adjusted prevalence, as well as adjusted prevalence ratios (aPRs) comparing respondents in each employment status and 2022 COVID-19/Long COVID category combination to the reference group (respondents in that employment status in 2019). We calculated 95% CIs; we considered (a) prevalence with non-overlapping CIs to be statistically significantly different (a conservative approach) and (b) aPRs with CIs not spanning the null to be statistically significant.

In the regression analyses, we adjusted for age (25–29, 30–34, 35–39, 40–44, 45–59, 50–54), sex (male, female), race/Hispanic ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, Hispanic, non-Hispanic other), cigarette smoking (current, former, never), and body-mass index (BMI) in kg/m^2 (< 25, $25-< 30$, $30-< 40$, $>= 40$). Some respondents meeting our study criteria were missing values for these characteristics. The BRFSS program provides imputed values for missing age and race/ethnicity. In 2019, 1.7% were missing age and 1.8% were missing race/ethnicity before imputation; in 2022, 2.2% were missing age and 3.0% were missing race/ethnicity before imputation. Sex was not missing for any respondents in either year. Smoking was missing for 4.2% in 2019 and 6.8% in 2022. In 2019, 8.3% of respondents and in 2022, 10.2% of respondents were missing data for weight and/or height, with more missing data for weight than for height. We did not impute missing values for smoking or for height and weight. We used the pairwise deletion method (available-case analysis) to handle missing data, where only respondents missing values on involved variables were removed from each pertinent analysis. Sample size details are included in Supporting Information S1: Appendix 1. We also conducted a secondary analysis with adjustment limited to age, sex, and race/Hispanic ethnicity (Supporting Information S1: Appendix 2). For comparability with Table 2, we also excluded respondents missing data for smoking, height, or weight, even though we did not adjust for those variables in the secondary analysis.

3 | Results

Of 418,268 respondents to the 2019 survey, 136,384 met age (25–54 years) and employment status (employed, self-employed, short-term unemployed, long-term unemployed, or unable to work) inclusion criteria. In 2022, of 445,132 respondents, 149,675 respondents met these criteria. In 2022, respondents who were missing information about COVID-19 ($n = 16{,}279$, 10.9%) or, among those who reported having had COVID-19 ($n = 53{,}614$), were missing Long COVID history ($n = 1163$, 2.2%) were included in the study population but excluded from analyses involving COVID-19, or COVID-19 and Long COVID. After these exclusions, 133,396 respondents were retained for the COVID-19 analyses and 52,451 for the Long COVID analyses.

3.1 | Changes in Prevalence of Chronic Conditions, 2019 to 2022

Among all included respondents, the unadjusted prevalence of ever asthma, current asthma, and diabetes increased significantly between 2019 and 2022 (Table 1), with ever asthma increasing from 14.8% (95% CI: 14.5, 15.1) to 15.7% (95% CI: 15.3, 16.0), current asthma from 8.8% (95% CI: 8.5, 9.1) to 9.9% (95% CI: 9.6, 10.2), and diabetes from 6.2% (95% CI: 6.0, 6.5) to 6.8% (95% CI: 6.5, 7.0). These increases were driven largely by increased prevalence among those employed for wages. Other conditions had significant increases only in specific employment categories: arthritis among employed respondents and stroke among the long-term unemployed.

3.2 | Prevalence of Chronic Conditions by 2022 COVID-19/Long COVID History Compared to 2019 Baseline by Employment Status

Among respondents with Long COVID, the unadjusted prevalence figures for all conditions increased and aPRs comparing

TABLE 1 | Weighted, unadjusted prevalence (%, 95% confidence interval) of chronic conditions 2019 versus 2022 by employment status[a] among respondents of prime working age (25–54 years) in the Behavioral Risk Factor Surveillance System[b].

Chronic condition[c]	Employment status	Unadjusted prevalence 2019 (95% CI)	Unadjusted prevalence 2022 (95% CI)
Coronary Heart Disease (myocardial infarction, angina, or coronary heart disease)	Overall[d]	2.5 (2.4, 2.7)	2.6 (2.4, 2.7)
	Employed for wages	1.6 (1.5, 1.7)	1.7 (1.5, 1.8)
	Self-employed	2.3 (1.9, 2.7)	2.4 (2.0, 3.0)
	Out of work for < 1 year	2.8 (2.2, 3.6)	2.6 (2.0, 3.3)
	Out of work for 1+ year	4.5 (3.6, 5.6)	6.0 (4.5, 7.8)
	Unable to work	12.3 (11.2, 13.5)	12.1 (10.9, 13.5)
Stroke	Overall[d]	1.7 (1.5, 1.8)	1.8 (1.6, 1.9)
	Employed for wages	0.8 (0.8, 0.9)	0.9 (0.8, 1.0)
	Self-employed	0.8 (0.6, 1.0)	1.4 (1.1, 1.8)
	Out of work for < 1 year	2.4 (1.7, 3.2)	1.9 (1.3, 2.5)
	Out of work for 1+ year	**2.0 (1.5, 2.5)**	**3.7 (2.7, 4.9)**
	Unable to work	11.6 (10.3, 12.9)	11.3 (10.0, 12.8)
Ever asthma	Overall[d]	**14.8 (14.5, 15.1)**	**15.7 (15.3, 16.0)**
	Employed for wages	**13.4 (13.0, 13.7)**	**14.5 (14.1, 14.9)**
	Self-employed	12.6 (11.7, 13.6)	12.3 (11.5, 13.2)
	Out of work for < 1 year	17.2 (15.2, 19.5)	17.8 (15.9, 19.8)
	Out of work for 1+ year	19.6 (17.3, 22.0)	20.9 (18.8, 23.2)
	Unable to work	31.0 (29.4, 32.6)	32.2 (30.3, 34.1)
Current asthma	Overall[d]	**8.8 (8.5, 9.1)**	**9.9 (9.6, 10.2)**
	Employed for wages	**7.4 (7.1, 7.7)**	**8.8 (8.5, 9.1)**
	Self-employed	6.9 (6.2, 7.7)	7.3 (6.7, 8.0)
	Out of work for < 1 year	10.7 (9.1, 12.3)	11.1 (9.7, 12.7)
	Out of work for 1+ year	12.6 (11.0, 14.4)	13.7 (11.9, 15.7)
	Unable to work	24.7 (23.2, 26.2)	25.5 (23.8, 27.2)
Chronic Obstructive Pulmonary Disease	Overall[d]	4.0 (3.8, 4.2)	3.7 (3.6, 3.9)
	Employed for wages	2.5 (2.3, 2.7)	2.4 (2.3, 2.6)
	Self-employed	3.2 (2.6, 3.7)	2.7 (2.3, 3.2)
	Out of work for < 1 year	4.6 (3.7, 5.6)	5.0 (3.9, 6.3)
	Out of work for 1+ year	7.9 (6.5, 9.5)	7.6 (6.2, 9.2)
	Unable to work	19.9 (18.6, 21.2)	18.3 (16.9, 19.9)
Kidney disease	Overall[d]	1.8 (1.7, 2.0)	2.0 (1.8, 2.1)
	Employed for wages	1.2 (1.0, 1.3)	1.3 (1.2, 1.5)
	Self-employed	1.4 (1.1, 1.8)	1.4 (1.2, 1.8)
	Out of work for < 1 year	2.1 (1.3, 3.2)	1.8 (1.3, 2.4)
	Out of work for 1+ year	3.5 (2.2, 5.3)	3.3 (2.4, 4.3)
	Unable to work	8.8 (7.9, 9.8)	9.9 (8.6, 11.2)
Diabetes (except gestational)	Overall[d]	**6.2 (6.0, 6.5)**	**6.8 (6.5, 7.0)**
	Employed for wages	**4.9 (4.7, 5.2)**	**5.6 (5.4, 5.9)**
	Self-employed	4.5 (3.9, 5.1)	5.7 (5.0, 6.4)
	Out of work for < 1 year	7.3 (5.6, 9.4)	7.5 (5.9, 9.5)
	Out of work for 1+ year	8.8 (7.3, 10.4)	9.3 (7.7, 11.2)

(Continues)

TABLE 1 | (Continued)

Chronic condition[c]	Employment status	Unadjusted prevalence 2019 (95% CI)	Unadjusted prevalence 2022 (95% CI)
	Unable to work	22.0 (20.6, 23.4)	20.5 (19.0, 22.2)
Arthritis	Overall[d]	15.4 (15.1, 15.7)	15.5 (15.1, 15.8)
	Employed for wages	**12.4 (12.1, 12.8)**	**13.1 (12.8, 13.5)**
	Self-employed	12.2 (11.4, 13.1)	13.3 (12.5, 14.3)
	Out of work for < 1 year	17.0 (15.1, 18.9)	16.3 (14.3, 18.5)
	Out of work for 1+ year	21.4 (19.3, 23.5)	20.7 (18.6, 23.0)
	Unable to work	49.6 (47.9, 51.4)	44.5 (42.5, 46.5)

Note: **Bolding** indicates statistically significant differences between 2019 and 2022 for a chronic condition-employment status combination based on prevalence with nonoverlapping 95% CIs.
[a]Excluding respondents not reporting employment status or self-reporting employment status as retired, homemaker, or student.
[b]New Jersey and US Virgin Islands were not included in 2019 and were thus excluded from 2022 analyses as well.
[c]Respondents answering "yes" to the question "Have you ever been told by a health provider that you have..." with each condition queried separately.
[d]Includes respondents who were employed, self-employed, out of work < 1 year, out of work >= 1 year, and unable to work.

2022 prevalence to the 2019 baseline had statistically significant elevations for respondents from all included employment statuses combined and for multiple specific employment statuses (Table 2). aPRs comparing 2022 prevalence to the 2019 baseline were most likely to be elevated among workers with Long COVID: employed respondents had significantly increased aPRs for every condition, and self-employed respondents had statistically significant elevations for stroke, ever and current asthma, diabetes, and arthritis. The aPRs for stroke exceeded 2.0 in the employed and 3.0 in the self-employed. Nonworking respondents with Long COVID also had statistically significant aPRs elevations: ever and current asthma, COPD, and arthritis in the short-term unemployed; stroke (aPR above 2.0) and kidney disease (aPR above 3.0) in the long-term unemployed; and MICHD, ever and current asthma, COPD, and arthritis among those unable to work.

Fewer statistically significant aPR elevations comparing 2022 to 2019 levels were observed among respondents not reporting Long COVID. However, among those who reported they had had COVID-19 but not Long COVID, aPRs were significantly elevated for some conditions: MICHD among those unable to work; ever and current asthma among those employed for wages; arthritis among the self-employed; and stroke in long-term unemployed. The only significant deficit in the COVID, no Long COVID group was for COPD in the combined employment status grouping. Respondents who had not had COVID-19 had significant aPR elevations only for current asthma among the employed and for stroke among self-employed but had statistically significant deficits for ever asthma among the self-employed, kidney disease among the long-term unemployed, diabetes among those unable to work, and arthritis among all included employment statuses combined as well as those unable to work.

When adjustment was limited to age, sex, and race/Hispanic ethnicity (i.e., without adjustment for smoking or BMI), the statistical significance of some aPRs changed (Supporting Information S2: Appendix 2). In most cases, point estimates were similar and the statistical significance of most results was unchanged. Without adjustment for BMI and smoking, point estimates for CHD, current asthma, diabetes, and arthritis were somewhat higher among employed and self-employed workers with Long COVID, although the statistical significance of these results did not change.

4 | Discussion

The increased burden of chronic disease from 2019 to 2022 observed in BRFSS data for adults of prime working age, particularly those with Long COVID, may have adverse consequences for individuals, the workplace, the healthcare system, and the economy. In our study, the prevalence of both current asthma and diabetes rose for the full study population from 2019 to 2022. When 2022 BRFSS respondents with Long COVID were compared with 2019 respondents in the same employment category, we observed statistically significant aPRs elevations for every included chronic condition among the employed, with statistically significant elevations for several conditions among self-employed and unemployed respondents with Long COVID. Increases of some chronic conditions among the much larger group of workers with a history of COVID but not Long COVID (asthma among employed and arthritis among self-employed workers) are also concerning.

In prior research unrelated to Long COVID, chronic diseases with elevated prevalence in our study have been associated with adverse economic consequences. Costs estimates for asthma include both direct costs (hospital, physician, medication) and indirect costs such as work absence, lost earnings due to early death, retirement, or disability exit, lost workplace productivity, lost home productivity, decreased employment, presenteeism, cost of job change due to illness, and economic impacts of care by family members [29, 30]. Nationally, adults with COPD were more likely to report being unable to work (24.3%) compared with those without COPD (5.3%) [31]. In addition, adults aged 40–70 with COPD were more likely than those without COPD to be unable to work (33.3% vs. 7.4%); retired (18.2% vs. 12.2%), or out of work for at least a year (6.2% vs. 3.8%) [32]. Both MICHD and stroke have large associated costs as well. In the United States, annual costs for MICHD

TABLE 2 | 2022 Prevalence (%, 95% confidence interval) of chronic conditions among BRFSS respondents[a] ages 25–54 years by self-reported COVID-19 and Long COVID status compared to 2019 prevalence for each included employment status[b].

			2022 Unadjusted prevalence[c] Adjusted prevalence ratio (aPR) compared to 2019[d]		
		2019 Unadjusted prevalence[c]		COVID-19, no Long	
Chronic condition	**Employment status**	**Adjusted prevalence[d]**	**No COVID-19**	**COVID**	**Long COVID**
Coronary Heart Disease (myocardial infarction, angina, or coronary heart disease)	Overall[e]	2.5 (2.4, 2.7)	2.6 (2.4, 2.8)	2.2 (1.9, 2.5)	3.8 (3.3, 4.3)
		2.5 (2.4, 2.7)	0.99 (0.90, 1.09)	0.92 (0.81, 1.04)	**1.48 (1.28, 1.72)**
	Employed for wages	1.6 (1.5, 1.7)	1.6 (1.5, 1.8)	1.5 (1.3, 1.7)	2.6 (2.1, 3.1)
		1.7 (1.6, 1.9)	0.98 (0.84, 1.13)	0.95 (0.81, 1.13)	**1.64 (1.33, 2.03)**
	Self-employed	2.3 (1.9, 2.7)	2.3 (1.9, 2.7)	1.9 (1.3, 2.8)	2.8 (1.8, 4.1)
		2.1 (1.7, 2.6)	1.05 (0.80, 1.38)	0.94 (0.62, 1.42)	1.28 (0.82, 2.01)
	Out of work for < 1 year	2.8 (2.2, 3.6)	2.4 (1.6, 3.3)	***	***
		3.1 (2.4, 3.9)	0.79 (0.51, 1.23)	0.90 (0.47, 1.74)	1.95 (0.96, 3.93)
	Out of work for 1+ year	4.5 (3.6, 5.6)	6.0 (4.0, 8.6)	***	6.6 (3.7, 10.8)
		4.0 (3.1, 5.1)	1.30 (0.82, 2.06)	1.05 (0.51, 2.17)	1.48 (0.84, 2.60)
	Unable to work	12.3 (11.2, 13.5)	11.1 (9.7, 12.7)	15.1 (11.0, 19.9)	15.8 (12.2, 19.9)
		8.3 (7.5, 9.2)	0.91 (0.78, 1.08)	**1.27 (1.00, 1.62)**	**1.37 (1.05, 1.78)**
Stroke	Overall[e]	1.7 (1.5, 1.8)	1.8 (1.6, 2.0)	1.4 (1.1, 1.7)	2.8 (2.3, 3.4)
		1.6 (1.5, 1.8)	1.06 (0.94, 1.20)	0.91 (0.77, 1.07)	**1.71 (1.39, 2.10)**
	Employed for wages	0.8 (0.8, 0.9)	0.9 (0.8, 1.1)	0.8 (0.6, 0.9)	1.9 (1.5, 2.4)
		0.9 (0.8, 1.0)	1.08 (0.89, 1.32)	0.99 (0.79, 1.26)	**2.35 (1.82, 3.03)**
	Self-employed	0.8 (0.6, 1.0)	1.3 (0.9, 1.7)	0.8 (0.5, 1.2)	***
		0.7 (0.5, 0.9)	**1.89 (1.27, 2.82)**	1.18 (0.73, 1.93)	**3.64 (1.65, 8.05)**
	Out of work for < 1 year	2.4 (1.7, 3.2)	1.7 (1.0, 2.7)	1.6 (0.8, 2.7)	***
		2.3 (1.7, 3.1)	0.72 (0.41, 1.25)	0.79 (0.42, 1.48)	1.89 (0.88, 4.08)
	Out of work for 1+ year	2.0 (1.5, 2.5)	3.1 (2.0, 4.7)	***	***
		1.7 (1.3, 2.2)	1.58 (0.95, 2.64)	**2.56 (1.30, 5.04)**	**2.81 (1.27, 6.23)**
	Unable to work	11.6 (10.3, 12.9)	10.9 (9.4, 12.6)	13.2 (9.1, 18.2)	10.7 (7.1, 15.2)
		8.3 (7.3, 9.4)	0.92 (0.77, 1.12)	1.06 (0.81, 1.39)	0.98 (0.64, 1.49)
Ever asthma	Overall[e]	14.8 (14.5, 15.1)	14.6 (14.2, 15.1)	15.5 (14.8, 16.2)	24.4 (23.0, 25.9)
		15.1 (14.8, 15.5)	1.00 (0.96, 1.03)	1.03 (0.98, 1.08)	**1.45 (1.36, 1.56)**
	Employed for wages	13.4 (13.0, 13.7)	13.5 (13.0, 14.0)	14.7 (14.0, 15.5)	22.7 (21.0, 24.5)
		13.7 (13.3, 14.1)	1.01 (0.97, 1.06)	**1.08 (1.02, 1.14)**	**1.50 (1.38, 1.63)**
	Self-employed	12.6 (11.7, 13.6)	11.2 (10.1, 12.3)	13.2 (11.2, 15.3)	19.0 (15.7, 22.6)
		14.2 (13.2, 15.3)	**0.87 (0.77, 0.98)**	1.00 (0.84, 1.18)	**1.32 (1.08, 1.61)**
	Out of work for < 1 year	17.2 (15.2, 19.5)	14.7 (12.5, 17.3)	16.2 (13.0, 19.9)	33.3 (26.2, 41.0)
		17.1 (15.0, 19.4)	0.85 (0.69, 1.04)	0.89 (0.70, 1.14)	**1.74 (1.33, 2.29)**
	Out of work for 1+ year	19.6 (17.3, 22.0)	20.4 (17.7, 23.3)	19.6 (15.3, 24.5)	27.9 (18.2, 39.5)
		17.9 (16.0, 20.0)	1.13 (0.94, 1.35)	1.09 (0.84, 1.41)	1.34 (0.89, 2.02)
	Unable to work	31.0 (29.4, 32.6)	29.7 (27.4, 32.1)	32.5 (27.8, 37.5)	43.9 (38.0, 49.9)
		29.1 (27.5, 30.8)	0.98 (0.89, 1.08)	0.97 (0.85, 1.12)	**1.32 (1.13, 1.55)**
Current asthma	Overall[e]	8.8 (8.5, 9.1)	9.1 (8.8, 9.5)	9.4 (8.9, 9.9)	17.7 (16.5, 19.1)
		9.0 (8.7, 9.3)	1.04 (0.99, 1.10)	1.04 (0.98, 1.11)	**1.66 (1.53, 1.81)**
	Employed for wages	7.4 (7.1, 7.7)	8.0 (7.6, 8.4)	8.7 (8.2, 9.3)	16.0 (14.5, 17.6)
		7.6 (7.4, 7.9)	**1.08 (1.01, 1.15)**	**1.15 (1.07, 1.24)**	**1.78 (1.59, 1.98)**
	Self-employed	6.9 (6.2, 7.7)	6.6 (5.8, 7.5)	7.4 (6.0, 9.0)	13.2 (10.5, 16.3)
		8.1 (7.3, 9.1)	0.91 (0.77, 1.09)	0.98 (0.79, 1.22)	**1.55 (1.20, 2.00)**
	Out of work for < 1 year	10.7 (9.1, 12.3)	9.1 (7.3, 11.1)	10.1 (7.6, 13.1)	23.4 (17.6, 30.2)

(Continues)

TABLE 2 | (Continued)

Chronic condition	Employment status	2019 Unadjusted prevalence[c] Adjusted prevalence[d]	2022 Unadjusted prevalence[c] Adjusted prevalence ratio (aPR) compared to 2019[d]		
			No COVID-19	COVID-19, no Long COVID	Long COVID
		10.6 (9.0, 12.3)	0.86 (0.67, 1.11)	0.91 (0.67, 1.24)	**1.87 (1.34, 2.61)**
	Out of work for 1+ year	12.6 (11.0, 14.4)	13.0 (10.8, 15.6)	12.0 (8.8, 15.7)	23.6 (13.9, 35.8)
		11.6 (10.1, 13.4)	1.10 (0.86, 1.39)	0.98 (0.71, 1.34)	1.63 (0.99, 2.66)
	Unable to work	24.7 (23.2, 26.2)	23.6 (21.5, 25.7)	25.3 (20.9, 30.1)	37.3 (31.7, 43.2)
		21.4 (20.0, 22.8)	0.99 (0.89, 1.11)	0.92 (0.78, 1.08)	**1.37 (1.14, 1.64)**
Chronic Obstructive Pulmonary Disease	Overall[e]	4.0 (3.8, 4.2)	3.8 (3.5, 4.0)	3.1 (2.8, 3.4)	6.2 (5.6, 6.9)
		4.0 (3.9, 4.2)	0.94 (0.87, 1.02)	**0.87 (0.78, 0.96)**	**1.41 (1.25, 1.58)**
	Employed for wages	2.5 (2.3, 2.7)	2.3 (2.1, 2.6)	2.2 (1.9, 2.5)	4.5 (3.9, 5.2)
		2.7 (2.5, 2.9)	0.96 (0.84, 1.09)	0.93 (0.82, 1.07)	**1.62 (1.38, 1.90)**
	Self-employed	3.2 (2.6, 3.7)	2.9 (2.2, 3.6)	2.3 (1.7, 3.0)	4.5 (3.3, 6.0)
		3.3 (2.8, 3.9)	0.84 (0.65, 1.09)	0.84 (0.60, 1.17)	1.24 (0.87, 1.78)
	Out of work for < 1 year	4.6 (3.7, 5.6)	4.6 (3.2, 6.2)	5.0 (2.5, 8.6)	8.2 (5.0, 12.5)
		4.2 (3.4, 5.2)	1.03 (0.70, 1.51)	1.22 (0.63, 2.34)	**1.85 (1.11, 3.06)**
	Out of work for 1+ year	7.9 (6.5, 9.5)	7.2 (5.2, 9.7)	7.6 (4.9, 11.1)	8.8 (5.2, 13.6)
		6.2 (5.1, 7.6)	0.98 (0.69, 1.40)	1.17 (0.74, 1.83)	0.97 (0.57, 1.65)
	Unable to work	19.9 (18.6, 21.2)	17.2 (15.5, 19.1)	18.5 (14.3, 23.3)	24.4 (19.9, 29.3)
		12.8 (11.9, 13.9)	0.90 (0.79, 1.03)	1.01 (0.82, 1.25)	**1.28 (1.02, 1.59)**
Kidney disease	Overall[e]	1.8 (1.7, 2.0)	1.9 (1.7, 2.1)	1.8 (1.5, 2.1)	2.9 (2.4, 3.5)
		1.8 (1.7, 2.0)	0.97 (0.84, 1.11)	0.96 (0.82, 1.13)	**1.44 (1.18, 1.76)**
	Employed for wages	1.2 (1.0, 1.3)	1.3 (1.1, 1.5)	1.2 (1.0, 1.4)	2.1 (1.6, 2.6)
		1.2 (1.1, 1.4)	1.04 (0.83, 1.30)	1.02 (0.82, 1.28)	**1.57 (1.18, 2.09)**
	Self-employed	1.4 (1.1, 1.8)	1.4 (1.0, 1.8)	1.4 (0.9, 2.3)	1.8 (1.0, 2.9)
		1.3 (1.0, 1.8)	1.07 (0.70, 1.64)	1.11 (0.65, 1.89)	1.17 (0.63, 2.15)
	Out of work for < 1 year	2.1 (1.3, 3.2)	1.3 (0.8, 2.1)	***	2.9 (1.6, 5.0)
		2.3 (1.5, 3.6)	**0.51 (0.26, 0.98)**	1.03 (0.47, 2.26)	1.16 (0.57, 2.35)
	Out of work for 1+ year	3.5 (2.2, 5.3)	2.7 (1.8, 3.7)	1.7 (0.9, 2.9)	***
		2.7 (2.0, 3.6)	0.86 (0.56, 1.31)	0.60 (0.31, 1.16)	**3.63 (1.65, 7.96)**
	Unable to work	8.8 (7.9, 9.8)	8.6 (7.2, 10.2)	13.3 (9.3, 18.2)	10.1 (7.4, 13.4)
		7.5 (6.5, 8.6)	0.88 (0.72, 1.07)	1.26 (0.96, 1.67)	1.13 (0.81, 1.57)
Diabetes (except gestational)	Overall[e]	6.2 (6.0, 6.5)	6.6 (6.2, 6.9)	6.6 (6.1, 7.1)	9.0 (8.0, 10.0)
		6.4 (6.2, 6.7)	1.01 (0.95, 1.08)	1.02 (0.94, 1.10)	**1.18 (1.05, 1.33)**
	Employed for wages	4.9 (4.7, 5.2)	5.6 (5.2, 6.0)	5.6 (5.2, 6.1)	7.1 (6.2, 8.0)
		5.4 (5.1, 5.7)	1.09 (1.00, 1.19)	1.07 (0.97, 1.18)	**1.19 (1.04, 1.37)**
	Self-employed	4.5 (3.9, 5.1)	4.9 (4.1, 5.8)	5.4 (4.2, 6.7)	9.0 (5.7, 13.3)
		4.7 (4.1, 5.3)	1.01 (0.83, 1.23)	1.15 (0.88, 1.51)	**1.76 (1.16, 2.65)**
	Out of work for < 1 year	7.3 (5.6, 9.4)	7.5 (5.1, 10.7)	6.5 (4.5, 9.2)	10.6 (6.4, 16.3)
		8.3 (6.5, 10.7)	0.99 (0.65, 1.51)	0.86 (0.56, 1.32)	1.08 (0.63, 1.85)
	Out of work for 1+ year	8.8 (7.3, 10.4)	8.4 (6.8, 10.4)	12.1 (7.2, 18.6)	***
		8.1 (6.8, 9.8)	0.91 (0.68, 1.22)	1.40 (0.86, 2.27)	1.01 (0.50, 2.03)
	Unable to work	22.0 (20.6, 23.4)	18.1 (16.4, 19.8)	24.6 (20.2, 29.4)	26.4 (21.1, 32.2)
		15.4 (14.3, 16.6)	**0.83 (0.74, 0.94)**	1.07 (0.90, 1.27)	1.05 (0.82, 1.35)
Arthritis	Overall[e]	15.4 (15.1, 15.7)	14.7 (14.3, 15.2)	14.8 (14.1, 15.5)	24.9 (23.5, 26.4)
		15.7 (15.4, 16.1)	**0.95 (0.92, 0.99)**	0.99 (0.94, 1.04)	**1.44 (1.36, 1.53)**
	Employed for wages	12.4 (12.1, 12.8)	12.1 (11.7, 12.6)	12.9 (12.2, 13.6)	20.8 (19.4, 22.3)

(Continues)

TABLE 2 | (Continued)

Chronic condition	Employment status	2019 Unadjusted prevalence[c] Adjusted prevalence[d]	2022 Unadjusted prevalence[c] Adjusted prevalence ratio (aPR) compared to 2019[d]		
			No COVID-19	COVID-19, no Long COVID	Long COVID
		13.3 (13.0, 13.7)	0.96 (0.92, 1.01)	1.04 (0.98, 1.10)	**1.48 (1.37, 1.60)**
	Self-employed	12.2 (11.4, 13.1)	12.1 (11.1, 13.3)	14.4 (12.5, 16.5)	25.7 (21.1, 30.8)
		12.8 (11.9, 13.7)	0.99 (0.89, 1.11)	**1.16 (1.00, 1.35)**	**1.94 (1.60, 2.34)**
	Out of work for < 1 year	17.0 (15.1, 18.9)	14.0 (11.1, 17.2)	15.7 (12.3, 19.6)	30.6 (23.6, 38.5)
		18.7 (16.8, 20.8)	0.87 (0.69, 1.09)	0.98 (0.78, 1.23)	**1.59 (1.23, 2.06)**
	Out of work for 1+ year	21.4 (19.3, 23.5)	19.8 (17.2, 22.6)	21.3 (15.9, 27.5)	31.5 (22.7, 41.5)
		19.8 (17.8, 21.9)	0.98 (0.82, 1.16)	1.17 (0.87, 1.58)	1.27 (0.92, 1.75)
	Unable to work	49.6 (47.9, 51.4)	42.8 (40.3, 45.4)	46.9 (42.0, 51.8)	59.5 (53.0, 65.8)
		39.0 (37.3, 40.8)	**0.88 (0.82, 0.95)**	0.96 (0.87, 1.07)	**1.15 (1.01, 1.32)**

Note: **Bolding** indicates statistically significant aPR (elevation or deficit) based on 95% confidence interval not spanning the null.
***Not reportable, Relative Standard Error (RSE) > 30%.
[a]Excluding respondents not reporting employment status or self-reporting employment status as retired, homemaker, or student.
[b]New Jersey and US Virgin Islands were not included in 2019 and were thus excluded from 2022 analyses as well.
[c]Weighted.
[d]Weighted and adjusted for age (25–29, 30–34, 35–39, 40–44, 45–59, 50–54), sex (male, female), race/Hispanic ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, Hispanic, non-Hispanic other), cigarette smoking (current, former, never), and body-mass index in kg/m^2 (< 25, 25–< 30, 30–< 40, > = 40).
[e]Includes respondents who were employed, self-employed, out of work < 1 year, out of work >= 1 year, and unable to work.

have been estimated at $320 billion for healthcare and lost productivity combined [33]. Other estimates put the average combined direct and indirect costs for 2018–2019 at $407.3 billion [34]. Mean labor income losses per person were estimated at $13,463 for heart disease and $18,716 for stroke in 2018, and total labor income losses at $203.3 billion for heart disease and $63.6 billion for stroke [35]. For stroke, additional needs such as caregiving costs, including long-term care in some cases, add to these costs.

The combination of Long COVID and chronic disease may exacerbate adverse employment consequences. Research using National Health Interview Survey (NHIS) data found missed workdays were twice as common among respondents with both Long COVID and cardiovascular disease than among those with cardiovascular disease alone (without Long COVID); missed workdays were also more common for respondents with Long COVID and diabetes than for those with diabetes alone, although the increase was smaller [18].

Our observation of elevated aPRs comparing the 2022 to 2019 prevalence of several conditions among the self-employed and short-term unemployed is also of concern. In the United States, self-employed and short-term unemployed adults of prime working age are less likely to have health insurance than those of other employment statuses [36]. Other research has found that cost was often a barrier to healthcare utilization among those affected by Long COVID [20]; thus, those respondents whose chronic conditions resulted from SARS-CoV-2 infection may have difficulty accessing treatments that can prevent worsening of those conditions. Other research suggests that access to such care plays a role in ensuring they can become or remain employed [37, 38].

Strengths of this study are that BRFSS is a large, national survey (although NJ and USVI could not be included in this study). In 2019, more than 136,000 respondents met inclusion criteria; in 2022, the total was nearly 150,000, including > 52,000 for the Long COVID analyses. The size of the study allows reportable prevalence estimates for even less common conditions for employed respondents and for many conditions for the smaller employment status categories.

The survey's cross-sectional design presents a major limitation for analyses comparing the prevalence of chronic conditions over time. This design precludes assessment of temporal relationships between SARS-CoV-2 infection, development of Long COVID symptoms, development of chronic conditions, including obesity and severe obesity, and changes in employment status. Previous research has reported increases in incident diagnoses of many chronic conditions following SARS-CoV-2 infection [8, 9, 12, 19, 39, 40]. Research on the incidence of asthma following SARS-CoV-2 has been mixed [41], although some studies using longitudinal data have observed increased risk following infection [19, 42]. The increased prevalence figures we observed among respondents with Long COVID could reflect (1) pre-existing chronic conditions or those developing after 2019 conferring higher likelihood of Long COVID; (2) greater ascertainment of Long COVID in the BRFSS survey among respondents with chronic conditions; (3) chronic conditions that were present but undiagnosed before infection with SARS-CoV-2 with a postinfection exacerbation leading to diagnoses; (4) new conditions resulting from SARS-CoV-2 infection; or (5) combined situations or other causes. While we cannot determine if the increased prevalence of chronic conditions observed among people with Long COVID in the current analyses is attributable to SARS-CoV-2 infection, other research is supportive of an association [9, 12, 19, 39, 40].

Another limitation pertains to covariates. Like all BRFSS data, BMI and smoking were self-reported. In 2019, BMI could not be calculated for more than 8% of respondents in our analytic data set and in 2022, for more than 10%. Other limitations of our study, discussed at length elsewhere, pertain primarily to misclassification of COVID-19 and Long COVID status stemming from the survey questions for these variables, as well as limitations and temporal changes in ascertainment [43].

Efforts to decrease the incidence of chronic conditions initiated or exacerbated by SARS-CoV-2 infection can benefit workers, employers, and the general public by limiting associated declines in well-being, ability to work, and healthcare costs. Staying up to date with immunization against SARS-CoV-2 has been shown to reduce the risk of developing Long COVID [44, 45]. Vaccination has been associated with reduced incidence of specific post-acute sequelae such as pulmonary embolism, hypertension, and diabetes [46]. Both Paxlovid (nirmatrelvir and ritonavir) and metformin have been found to decrease the risk of Long COVID in some studies [47–49]. More mechanistic research leading to effective treatments is needed [50]. In addition, efforts to prevent transmission of airborne respiratory viruses can reduce the number of acute cases, and thus long-term sequelae. Layered mitigation strategies such as provision of flexible, nonpunitive paid sick leave, ventilation and filtration, and the use of masks and respirators remain useful strategies for reducing workplace transmission [51–53]. The American Academy of Physical Medicine and Rehabilitation guidance on Long COVID symptoms and conditions provides strategies for managing Long COVID; many of these are applicable to the workplace [54]. Some occupations have been disproportionarely affected by Long COVID [55], and consideration of the workforce, workplace, and job tasks is critical to designing accommodations that facilitate continued employment of affected employees. For both the general public and workers, improved healthcare practitioner recognition and ascertainment of Long COVID, as well as improved treatment protocols, are critical aspects of addressing Long COVID.

In light of other research on the economic consequences of chronic conditions [29–35], the increased prevalence of chronic conditions observed in this study, particularly among respondents with Long COVID, are concerning. Although the risk of developing Long COVID has been found to be lower following infection with Omicron than with earlier common variants of SARS-CoV-2 [13, 44], the increased infectivity of the Omicron variants may continue to increase the associated chronic disease burden. Preventing and addressing the chronic conditions associated with Long COVID in this study, as well as other sequelae of COVID-19, is key to ensuring the health of the current and future workforce and the general public.

Author Contributions

Sharon Silver and Jia Li conceived the investigation and the paper. Sharon Silver led the writing of the paper. Jia Li conducted the analyses. Sharon Silver and Sharon Saydah provided contextualization for these findings within COVID-19 and Long COVID research. In addition, all authors have participated in a) interpretation of the data; b) drafting the article or revising it critically for important intellectual content; and c) approval of the final version. All authors approved the version to be published; all authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Disclosure

The findings and conclusions presented in this article are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health and the Centers for Disease Control and Prevention.

Ethics Statement

The BRFSS study protocol was reviewed and approved by institutional Review Board at CDC.

Conflicts of Interest

The authors declare no conflicts of interest.

Disclosure by AJIM Editor of Record

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

Data Availability Statement

The data that support the findings of this study are openly available at https://www.cdc.gov/brfss/annual_data/annual_2022.html and https://www.cdc.gov/brfss/annual_data/annual_2019.html.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.