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Prevalence of and factors associated with long COVID among US adults: a nationwide survey

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Abstract

Background People with long COVID report prolonged, multisystem involvement and significant disability. This study aimed to determine long COVID prevalence and factors associated with it among US adults using nationally representative data.

Methods This cross-sectional analysis utilized data from 2022 Behavioral Risk Factor Surveillance System survey, a nationally representative telephone survey conducted among noninstitutionalized adults aged ≥ 18 years residing in the United States. Age-adjusted prevalence of long COVID was calculated using weighted survey analysis. Poisson regression was employed to assess adjusted prevalence ratios (aPRs) associated with long COVID across various demographic, socioeconomic and health-related characteristics.

Results Among 390,233 participants, 120,178 reported COVID-19, with 25,582 experiencing long COVID. Age-adjusted prevalence of self-reported COVID-19 and long COVID were estimated at 34.1% (95% CI, 33.7–34.4%) and 7.2% (95% CI, 7.0–7.4%) as of 2022, respectively. Among adults reporting COVID-19, 20.9% (95% CI, 20.5–21.4%) had ever experienced long COVID. An inverted U-shaped association was observed between long COVID risk and age, with the highest prevalence (23.5%) in the 45–54 age group. Long COVID was more prevalent among women (aPR, 1.40 [95% CI, 1.34–1.47]), individuals without a spouse (aPR, 1.06 [95% CI, 1.00–1.13]), uninsured (aPR, 1.16 [95% CI, 1.06–1.27]), and those with a high school education (aPR, 1.17 [95% CI, 1.12–1.23]), cardiovascular disease (aPR, 1.17 [95% CI, 1.09–1.25]), depressive disorder (aPR, 1.41 [95% CI, 1.34–1.48]), chronic obstructive pulmonary disease (aPR, 1.33 [95% CI, 1.24–1.43]), asthma (aPR, 1.28 [95% CI, 1.21–1.35]), and kidney disease (aPR, 1.11 [95% CI, 1.01–1.21]). Long COVID was less prevalent among non-Hispanic Black (aPR, 0.87 [95% CI, 0.81–0.95]), students (aPR, 0.87 [95% CI, 0.76–0.99]) or retired individuals (aPR, 0.89 [95% CI, 0.82–0.98]), and those with household incomes ≥$100,000 (aPR, 0.85 [95% CI, 0.79–0.92]).

Conclusions Long COVID affects 7.2% of US adults, with higher vulnerability among women, middle-aged individuals, White individuals, socioeconomically disadvantaged groups, and those with chronic conditions. These findings underscore the need for targeted public health strategies to address disparities in long COVID burden and support high-risk populations.

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Keywords COVID-19, Long COVID, Epidemiology, BRFSS

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), has resulted in unprecedented levels of morbidity and mortality worldwide, including within the United States [1]. Beyond the acute phase of the illness, its subsequent phases present ongoing risks to health. Long COVID, a heterogeneous condition, encompasses signs and symptoms that persist or develop four or more weeks after the onset of acute COVID-19 symptoms [2]. It is estimated that 10–30% of non-hospitalized cases and 50–70% of hospitalized cases may experience long COVID [3, 4]. The condition is characterized by various manifestations across multiple organ systems, including but not limited to fatigue, dyspnea (shortness of breath), and cognitive impairment. Despite numerous clinical trials, effective treatments for long COVID are currently lacking [5]. Recent economic assessments suggest that long COVID may account for over 15% of the labor shortage in the United States [6].

Estimates of long COVID prevalence vary considerably depending on study design, population characteristics, and case definition [7]. In the United States, prevalence assessments predominantly rely on non-representative sources, including cross-sectional convenience samples, as well as analyses of electronic health records and cohorts [2, 4, 8, 9]. Two recent national surveys—the National Health Interview Survey (NHIS) and the US Household Pulse Survey (HPS)—have assessed long COVID prevalence in the general US adult population, yet their estimates vary significantly (6.9% vs. 14.0–15.7%) [10–12]. These discrepancies may stem from differences in response rates, survey design, population coverage, or timing of data collection.

Limited understanding exists regarding the risk factors for long COVID. Available data from the United States and Europe consistently indicate a higher prevalence of long COVID among women and individuals with comorbidities [7, 13–17]. However, identifying additional risk factors is challenging due to discrepancies arising from variations in study design, population demographics—typically focusing on hospitalized or healthcare-seeking cohorts—and the operational definition of long COVID [7, 13–17].

This study addresses critical gaps in current evidence by: (1) leveraging the Behavioral Risk Factor Surveillance System (BRFSS), one of the largest nationally representative health surveys, to provide more precise prevalence estimates of long COVID in non-institutionalized US adults; and (2) systematically examining sociodemographic and clinical risk factors in a general population sample, overcoming limitations of previous studies that relied primarily on clinical or convenience samples. Our findings will provide more generalizable evidence to inform public health strategies targeting at-risk populations.

Methods

Study population

The BRFSS is an ongoing telephone survey system collecting data on health-related behaviors, chronic conditions, healthcare access, and preventive service usage among noninstitutionalized adults aged 18 years or older in the US and its territories [18]. The BRFSS incorporates weighting adjustments to address demographic variances, noncoverage, and nonresponse, thus ensuring the representativeness of the data [19]. This cross-sectional analysis was based on the 2022 BRFSS survey, which collected data from all 50 states, the District of Columbia, and three territories (Guam, Puerto Rico, and the US Virgin Islands) through landline and cellular telephones. Verbal consent was obtained during the telephone interview [20]. The response rate for the 2022 BRFSS survey was 45.0%. This study included 390,233 participants (87.7% of the surveyed population) who reported COVID-19 information. Approval from the institutional review board was not sought for this study, as the data are publicly accessible and de-identified. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Assessment of SARS-CoV-2 infection and long COVID

SARS-CoV-2 infection was determined using the question: "Has a doctor, nurse, or other health professional ever told you that you tested positive for COVID-19?" Participants who responded affirmatively or reported testing positive using a home test without health professional involvement were classified as having SARS-CoV-2 infection. Those reporting SARS-CoV-2 infection were subsequently asked, "Did you have any symptoms lasting 3 months or longer that you did not have prior to having coronavirus or COVID-19?" An affirmative response led to classification as having long COVID. Respondents indicating long COVID were further queried about their primary symptom experienced. Response options included: (1) tiredness or fatigue; (2) difficulty thinking or concentrating or forgetfulness/memory problems (sometimes referred to as "brain fog"); (3) difficulty breathing or shortness of breath; (4) joint or muscle pain; (5) fast-beating or pounding heart (also known as heart palpitations) or chest pain; (6) dizziness on standing; (7) depression/anxiety or mood changes; (8) symptoms

that get worse after physical or mental activities; (9) you did not have any long-term symptoms that limited your activities; (10) loss of taste or smell; and (11) some other symptom. These questionnaires were similar to those employed in NHIS [11, 12].

Other study measures

Demographic and socioeconomic characteristics included age, sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic other, or Hispanic), marital status (married/unmarried couple, widowed/separated/divorced, or single), education level (less than high school, high school or some college, or college graduate), employment status (employed, unemployed, student, or retired), area of residence (rural or urban) [21, 22], health insurance status (having some form of insurance or being uninsured), and annual household income (<$35,000, $35,000-$99,999, or ≥$100,000).

Chronic conditions are defined as conditions lasting one year or more that require ongoing medical care, limit daily activities, or both [23]. Chronic conditions assessed included cardiovascular disease (myocardial infarction, coronary heart disease, or stroke), cancer (excluding non-melanoma skin cancer), depression, chronic obstructive pulmonary disease (COPD) (including emphysema or chronic bronchitis), asthma, and kidney disease (excluding kidney stones, bladder infection, or incontinence). Questionaries about chronic conditions are shown in Table S1. The inclusion of these chronic conditions in this study was based on prior evidence of association with long COVID [14, 16, 24–26], clinical plausibility, and data availability in BRFSS.

Statistical analysis

The age-adjusted prevalences of self-reported SARS-CoV-2 infection and long COVID were calculated for all adults aged 18 years and above. The Wald method was used to obtain 95% confidence intervals (CIs) for prevalence estimates. Demographic, socioeconomic, and health condition characteristics were summarized for the entire sample, as well as for individuals self-reporting SARS-CoV-2 infection and long COVID.

The age-adjusted proportion of adults self-reporting long COVID was calculated for all adults self-reporting SARS-CoV-2 infection. This proportion was determined for the overall adult population and within predefined categories, including age group (18–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, and ≥75 years), sex, race/ethnicity, marital status, education, employment, household income, area of residence, health insurance coverage, and chronic conditions. Age-adjusted proportion was calculated via direct standardization using 2020 US Census data [27]. The age categories used for standardization were 18 to 24 years (12.1%), 25 to 34 years (17.6%), 35 to 44 years (16.6%), 45 to 54 years (15.9%), 55 to 64 years (16.6%), 65 to 74 years (12.5%), and 75 years or older (8.7%). Age-adjusted estimates account for the substantial variation in long COVID prevalence across age groups. It is particularly important for surveillance data as it controls for differences in population age structures when making comparisons [28–31].

Poisson regression was employed to assess prevalence ratios associated with long COVID across various demographic, socioeconomic and health-related characteristics, including age group, sex, race/ethnicity, marital status, education, employment, household income, area of residence, health insurance coverage, and chronic conditions. Poisson regression provides correct estimates and is a better alternative for the analysis of cross-sectional studies with binary outcomes than logistic regression, since the prevalence ratio is more interpretable and easier to communicate to non-specialists than the odds ratio [32, 33]. Two Poisson regression models were employed: Model 1, adjusting for age group, sex, and race/ethnicity, and Model 2 adjusting for all aforementioned variables.

Missing data were multiply imputed by chained equations and five imputed datasets were generated. A complete analysis was also conducted to assess factors associated with long COVID. Survey weights were applied in all calculations to yield nationally representative estimates [19]. Statistically significance was defined as $p < 0.05$ (two-tailed). StataSE 15 statistical software (StataCorp) was used for all analyses.

Results

In 2022, the BRFSS surveyed 445,132 adults aged 18 or older. Participants were excluded if they either lacked COVID-19 test results or had such results but lacked information regarding long COVID, leaving 390,233 participants for analysis. Among these, 120,178 self-reported SARS-CoV-2 infection, of whom 25,582 had experienced long COVID (Fig. 1).

Of the 390,233 participants included in the analysis, 183,884 (48.9%) were men and 206,349 (51.1%) were women. Participants aged over 65 years constituted 23.5% of the study population. A total of 60.3% of participants identified as non-Hispanic White adults, 11.2% as non-Hispanic Black adults, 17.9% as Hispanic adults, and 10.6% as other race or ethnicity (Table 1). No participants were missing data on age, sex, or race/ethnicity. There were missing data for marital status (0.8% of participants), education (0.4%), employment (0.9%), household income (18.0%), area of residence (2.3%), health insurance coverage (3.6%), cardiovascular disease (0.1%), cancer (0.5%), depressive disorder (0.6%), COPD (0.4%), asthma (0.4%), and kidney disease (0.4%).

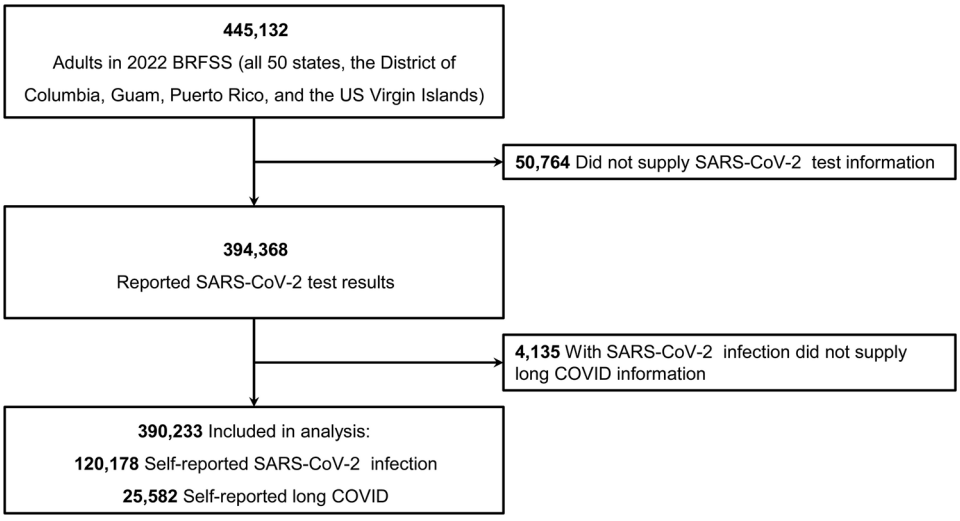

Fig. 1 Determination of the study sample. BRFSS, the Behavioral Risk Factor Surveillance System; COVID, coronavirus disease

Prevalence of ever having long COVID

The age-adjusted prevalences of self-reported SARS-CoV-2 infection and ever having long COVID were estimated at 34.1% (95% CI, 33.7–34.4%) and 7.2% (95% CI, 7.0–7.4%), respectively, as of 2022. This corresponds to approximately 87,906,518 and 18,603,304 US adults affected by COVID-19 and long COVID, respectively. Among primary long COVID symptoms, tiredness or fatigue predominated (26.2%), followed by difficulty breathing or shortness of breath (18.9%), loss of taste or smell (17.0%), some other symptoms (9.9%), brain fog (difficulty thinking or concentrating or forgetfulness/memory problems) (9.8%), joint or muscle pain (6.2%), symptoms not limiting activities (5.2%), heart palpitations or chest pain (2.9%), dizziness on standing (1.6%), depression/anxiety or mood changes (1.4%), and symptoms worsening after physical or mental activities (0.9%).

Among adults with self-reported COVID-19, the age-adjusted estimated proportion of ever having long COVID was 20.9% (95% CI, 20.5–21.4%). The estimated proportions of adults ever having long COVID by the categories of age group, sex, race/ethnicity, marital status, education, employment, household income, area of residence, health insurance coverage, and comorbidities among those with self-reported SARS-CoV-2 infection appear in Table 2.

Factors associated with self-reported long COVID

Compared with adults aged 18 to 24 years with self-reported SARS-CoV-2 infection, long COVID was more prevalent among their counterparts aged 25 to 34 years (20.6% vs. 17.8%; adjusted prevalence ratio [aPR], 1.14 [95% CI, 1.04–1.25]), 35 to 44 years (23.4% vs. 17.8%; aPR, 1.30 [95% CI, 1.18–1.43]), 45 to 54 years (23.5% vs. 17.8%; aPR, 1.31 [95% CI, 1.18–1.45]), and 55 to 64 years (22.2% vs. 17.8%; aPR, 1.19 [95% CI, 1.07–1.32]). The proportion of long COVID declined in those aged ≥ 65, with no significant difference compared with the 18 to 24 years age group (Table 2; Fig. 2). Long COVID was more prevalent among women than men (24.9% vs. 16.3%; aPR, 1.40 [95% CI, 1.34–1.47]). Long COVID was less prevalent among non-Hispanic Black (18.9%) and non-Hispanic other adults (19.3%) compared with non-Hispanic White adults (21.4%) (aPR, 0.87 [95% CI, 0.81–0.95], and 0.91 [95% CI, 0.83–1.00], respectively).

Long COVID was more prevalent among adults who were widowed, separated, or divorced compared with those in marital or unmarried couple arrangements (26.8% vs. 20.0%; aPR, 1.06 [95% CI, 1.00–1.13]). Long COVID was more prevalent among adults with a high school education or some college education compared with those with a college graduate education (22.6% vs. 17.6%; aPR, 1.17 [95% CI, 1.12–1.23]), as well as among adults lacking any form of health insurance compared with those with coverage (22.4% vs. 20.7%; aPR, 1.16 [95% CI, 1.06–1.27]). Long COVID was less prevalent among adults who were students (18.9%) or retired (17.3%) compared with those employed (19.6%) (aPR, 0.87 [95% CI, 0.76–0.99], and 0.89 [95% CI, 0.82–0.98], respectively), as well as among adults with household income at or above $100,000 compared with those earning less than $35,000 (16.5% vs. 25.2%; aPR, 0.85 [95% CI, 0.79–0.92]). Additionally, long COVID was more prevalent among adults with cardiovascular disease (aPR, 1.17 [95% CI, 1.09–1.25]), depressive disorder (aPR, 1.41 [95% CI, 1.34–1.48]), COPD (aPR, 1.33 [95% CI, 1.24–1.43]), asthma (aPR, 1.28 [95% CI, 1.21–1.35]), and kidney disease (aPR, 1.11 [95% CI, 1.01–1.21]). The results were similar in a complete case analysis (Table S2).

Table 1 Participant characteristics overall and among those with self-reported COVID-19 and long COVID, 2022 Behavioral Risk Factor Surveillance System[a]

Characteristic	Total		COVID-19		Long COVID	
	Number (*N* = 390,233)	Proportion (95% CI)	Number (*N* = 120,178)	Proportion (95% CI)	Number (*N* = 25,582)	Proportion (95% CI)
Sex						
Male	183,884	48.9 (48.6–49.2)	55,250	46.7 (46.1–47.3)	9,154	36.4 (35.2–37.6)
Female	206,349	51.1 (50.8–51.4)	64,928	53.3 (52.7–53.9)	16,428	63.6 (62.4–64.8)
Age, years						
18–24	23,663	12.1 (11.8–12.3)	9,549	14.0 (13.5–14.4)	1,677	11.8 (10.9–12.6)
25–34	41,629	16.9 (16.7–17.2)	17,047	20.2 (19.7–20.6)	3,475	19.7 (18.7–20.7)
35–44	51,080	16.2 (15.9–16.4)	20,244	19.0 (18.5–19.4)	4,652	21.1 (20.0–22.2)
45–54	57,238	15.0 (14.8–15.3)	20,907	16.2 (15.8–16.6)	5,071	18.0 (17.1–19.0)
55–64	72,432	16.3 (16.1–16.5)	21,935	15.1 (14.7–15.5)	5,025	15.9 (15.1–16.8)
65–74	82,809	14.0 (13.8–14.2)	19,456	10.4 (10.1–10.8)	3,806	9.6 (8.9–10.3)
≥75	61,382	9.5 (9.3–9.7)	11,040	5.1 (4.9–5.3)	1,876	4.0 (3.6–4.3)
Race and ethnicity						
Non-Hispanic White	295,022	60.3 (59.9–60.6)	88,476	59.2 (58.6–59.8)	18,857	60.2 (58.9–61.6)
Non-Hispanic Black	29,930	11.2 (11.0–11.4)	8,843	10.7 (10.3–11.0)	1,688	9.9 (9.1–10.6)
Non-Hispanic other	28,233	10.6 (10.4–10.9)	8,988	10.5 (10.0–10.9)	1,898	9.3 (8.5–10.2)
Hispanic	37,048	17.9 (17.6–18.2)	13,871	19.7 (19.1–20.2)	3,139	20.5 (19.3–21.8)
Marital status						
Married/unmarried couple	216,110	55.1 (54.8–55.4)	71,797	57.9 (57.3–58.5)	14,624	56.3 (55.0–57.5)
Single	69,960	25.0 (24.7–25.3)	22,729	26.0 (25.5–26.6)	4,571	24.0 (22.9–25.1)
Widowed/separated/divorced	100,958	19.9 (19.6–20.1)	24,832	16.1 (15.7–16.5)	6,216	19.7 (18.8–20.7)
Highest education level						
Less than high school	22,041	11.4 (11.2–11.7)	5,878	9.2 (8.7–9.6)	1,371	10.2 (9.2–11.2)
High school or some college	200,061	57.7 (57.3–58.0)	61,611	58.6 (58.0–59.2)	14,571	62.5 (61.3–63.7)
College graduate	166,660	30.9 (30.6–31.2)	52,310	32.2 (31.8–32.7)	9,566	27.3 (26.3–28.2)
Employment status						
Employed	198,546	57.2 (56.9–57.5)	74,435	66.0 (65.5–66.6)	15,482	64.3 (63.1–65.5)
Unemployed	54,018	16.7 (16.5–17.0)	15,305	14.5 (14.1–14.9)	4,492	19.4 (18.4–20.4)
Student	10,043	5.0 (4.8–5.2)	3,909	5.8 (5.5–6.1)	661	4.5 (3.9–5.1)
Retired	124,147	21.1 (20.8–21.3)	25,609	13.7 (13.3–14.1)	4,777	11.8 (11.0-12.5)
Annual household income						
<$35,000	89,099	30.9 (30.6–31.3)	23,806	26.4 (25.9–27.0)	6,384	30.8 (29.6–32.0)
$35,000–$99,999	142,020	41.5 (41.1–41.8)	45,320	42.3 (41.7–42.9)	9,969	43.6 (42.1–45.0)
≥$100,000	88,701	27.6 (27.3–27.9)	32,504	31.3 (30.8–31.9)	5,629	25.6 (24.4–26.8)
Area of residence						
Rural	49,186	6.4 (6.3–6.6)	14,306	5.9 (5.7–6.1)	3,502	6.6 (6.2–7.0)
Urban	332,269	93.6 (93.4–93.7)	102,884	94.1 (93.9–94.3)	21,622	93.4 (93.0–94.5)
Health insurance						
Yes	356,738	91.6 (91.4–91.8)	110,800	93.0 (92.6–93.3)	23,352	91.7 (90.9–93.7)
No	19,492	8.4 (8.2–8.6)	5,628	7.0 (6.7–7.4)	1,501	8.3 (7.5–9.1)
Cardiovascular disease						
Yes	46,253	9.2 (9.0–9.4)	12,070	7.6 (7.3–7.9)	3,231	9.7 (9.1–10.3)
No	343,680	90.8 (90.6–91.0)	108,044	92.4 (92.1–92.7)	22,334	90.3 (89.7–90.9)
Cancer						
Yes	45,066	8.4 (8.2–8.5)	11,736	7.2 (6.9–7.4)	2,663	7.9 (7.2–8.5)
No	343,224	91.6 (91.5–91.8)	108,001	92.8 (92.6–93.1)	22,809	92.1 (91.5–92.8)
Depressive disorder						
Yes	81,736	21.1 (20.9–21.4)	27,931	23.5 (23.0–24.0)	8,455	34.1 (32.9–35.3)
No	306,275	78.9 (78.6–79.1)	91,642	76.5 (76.0–77.0)	16,957	65.9 (64.7–67.1)
COPD						
Yes	31,356	6.9 (6.7–7.0)	8,671	6.1 (5.8–6.3)	2,985	10.2 (9.5–10.9)
No	357,153	93.1 (93.0-93.3)	111,051	93.9 (93.7–94.2)	22,452	89.8 (89.1–90.5)

Table 1 (continued)

Characteristic	Total		COVID-19		Long COVID	
	Number (*N* = 390,233)	Proportion (95% CI)	Number (*N* = 120,178)	Proportion (95% CI)	Number (*N* = 25,582)	Proportion (95% CI)
Asthma						
Yes	58,904	15.4 (15.1–15.6)	20,821	17.6 (17.2–18.1)	6,264	24.4 (23.3–25.4)
No	329,939	84.6 (84.4–84.9)	98,983	82.4 (81.9–82.8)	19,198	75.6 (74.5–76.7)
Kidney disease						
Yes	18,081	3.7 (3.6–3.8)	5,095	3.4 (3.2–3.6)	1,420	4.6 (4.1–5.0)
No	370,665	96.3 (96.2–96.4)	114,696	96.6 (96.4–96.8)	24,052	95.4 (95.0–95.9)

a Weighted proportions and 95% confidence intervals were calculated in consideration of the complex sampling design of the Behavioral Risk Factor Surveillance System survey. COPD, chronic obstructive pulmonary disease

Discussion

Utilizing nationally representative data from the 2022 BRFSS, this study provides robust population-level estimates of long COVID prevalence and associated risk factors among US adults. Our findings indicate that 7.2% (95% CI, 7.0–7.4%) of the adult population, equating to around 18.6 million individuals, reported experiencing long COVID as of 2022, defined as persistent symptoms lasting three months or longer following SARS-CoV-2 infection. Notably, the risk exhibited an inverted U-shaped association with age, with the highest prevalence observed among middle-aged adults (45–54 years), followed by a gradual decline in older age groups. Furthermore, significant disparities were identified across demographic and clinical subgroups, with elevated risk among women, non-Hispanic White individuals, those with lower socioeconomic status (e.g., lower education, uninsured status, and lower household income), and individuals without a spouse. Additionally, pre-existing chronic conditions such as depressive disorder, COPD, asthma, cardiovascular disease, and kidney disease, were associated with increased susceptibility to long COVID.

Our BRFSS-based estimate of long COVID prevalence (7.2%) closely aligns with the 2022 NHIS estimate (6.9%), despite the substantial difference in sample sizes (445,132 vs. 27,651 respondents) [11, 34]. This consistency between two large, nationally representative surveys employing similar methodology strengthens confidence in these prevalence estimates. However, both estimates are notably lower than the 14.0-15.7% range reported by the HPS [10]. Several key methodological differences likely explain this discrepancy. First, the HPS included both laboratory-confirmed cases and clinically diagnosed COVID-19, while BRFSS and NHIS restricted their assessment to test-confirmed cases. This distinction is particularly relevant given emerging evidence that long-term symptoms can occur at similar rates among individuals with COVID-like illness regardless of test results [35]. Second, the HPS's substantially lower response rate (3.9-7.3% vs. 45.0% for BRFSS and 47.7% for NHIS) and reliance on digital recruitment methods may have introduced selection biases that affected prevalence estimates. These methodological considerations underscore the importance of standardized case definitions and sampling approaches in long COVID surveillance.

The age-adjusted estimated proportion of individuals with long COVID among US adults self-reporting COVID-19 in the BRFSS was 20.9% (95% CI, 20.5–21.4%). Previous studies have reported varying estimates, ranging from 9 to 52%, depending on factors such as acute phase severity, geographic region, sociodemographic characteristics, case definitions, sample sizes, COVID waves, and follow-up durations [7]. These earlier estimates were derived from non-population representative sources. In contrast, the BRFSS, as a population-representative survey, offers a valuable means of assessing the magnitude of long COVID in the United States.

The most prevalent primary symptoms of long COVID identified in the BRFSS were tiredness or fatigue, difficulty breathing or shortness of breath, loss of taste or smell, and brain fog (difficulty concentrating or memory problems). These findings are consistent with previous reports and correspond to the three symptoms explicitly included in the World Health Organization's definition of long COVID [7, 36]. Our findings are also consistent with studies characterizing the multisystem involvement of long COVID [37–40].

Our analyses reveal an inverted U-shaped association between long COVID risk and age, with the highest risk observed among individuals aged 35–44 and 45–54 years. The risk declines among individuals aged over 65, with no increased risk compared with the reference group aged 18–24. The decline of long COVID risk among older individuals was also observed in prior studies [15, 16]. The underlying influential factors may include selective competing risk of mortality, non-response bias, reduced symptom reporting among the elderly, and misattribution of long COVID symptoms to other illnesses [16]. The finding that the prevalence of long COVID was 40% higher in women than men is consistent with the majority of previous studies [7, 41]. Additionally, our study found that Black individuals, but not Hispanic individuals, reported a lower incidence of long COVID compared to White individuals, consistent with findings from

Table 2 Prevalence of and associated factors with long COVID among adults with self-reported COVID-19 infection, 2022 Behavioral Risk Factor Surveillance System[a]

Characteristic	Adults with COVID ($n=120,178$)[b]	Prevalence ratio (95% CI)	
	Prevalence, % (95% CI)[c]	Model 1[d]	Model 2[e]
Total	20.9 (20.5–21.4)		
Sex			
Male	16.3 (15.7–16.9)	1 [Reference]	1 [Reference]
Female	24.9 (24.2–25.6)	1.53 (1.46–1.60)	1.40 (1.34–1.47)
Age, years			
18–24	17.8 (16.5–19.0)	1 [Reference]	1 [Reference]
25–34	20.6 (19.5–21.6)	1.15 (1.05–1.25)	1.14 (1.04–1.25)
35–44	23.4 (22.2–24.6)	1.30 (1.19–1.42)	1.30 (1.18–1.43)
45–54	23.5 (22.3–24.6)	1.31 (1.20–1.43)	1.31 (1.18–1.45)
55–64	22.2 (21.1–23.4)	1.23 (1.13–1.35)	1.19 (1.07–1.32)
65–74	19.4 (18.1–20.7)	1.07 (0.97–1.18)	1.04 (0.92–1.17)
≥75	16.3 (14.8–17.8)	0.89 (0.79–1.00)	0.88 (0.76–1.03)
Race and ethnicity			
Non-Hispanic White	21.4 (20.9–21.9)	1 [Reference]	1 [Reference]
Non-Hispanic Black	18.9 (17.5–20.3)	0.87 (0.81–0.94)	0.87 (0.81–0.95)
Non-Hispanic other	19.3 (17.3–21.4)	0.87 (0.79–0.95)	0.91 (0.83–1.00)
Hispanic	21.0 (19.5–22.4)	1.01 (0.94–1.08)	0.99 (0.92–1.06)
Marital status			
Married/unmarried couple	20.0 (19.4–20.6)	1 [Reference]	1 [Reference]
Single	20.8 (19.1–22.6)	1.04 (0.97–1.11)	0.96 (0.90–1.02)
Widowed/separated/divorced	26.8 (25.1–28.6)	1.24 (1.18–1.32)	1.06 (1.00–1.13)
Highest education level			
Less than high school	23.1 (21.0–25.2)	1.36 (1.23–1.51)	1.10 (0.99–1.22)
High school or some college	22.6 (22.0–23.3)	1.32 (1.26–1.38)	1.17 (1.12–1.23)
College graduate	17.6 (16.9–18.2)	1 [Reference]	1 [Reference]
Employment status			
Employed	19.6 (19.0-20.3)	1 [Reference]	1 [Reference]
Unemployed	27.8 (26.3–29.3)	1.28 (1.21–1.36)	1.03 (0.97–1.10)
Student	18.9 (13.6–24.2)	0.88 (0.77–1.01)	0.87 (0.76–0.99)
Retired	17.3 (11.1–23.5)	0.97 (0.89–1.05)	0.89 (0.82–0.98)
Household income			
<$35,000	25.2 (24.2–26.2)	1 [Reference]	1 [Reference]
$35,000–$99,999	21.7 (21.0–22.5)	0.88 (0.83–0.93)	1.00 (0.94–1.07)
≥$100,000	16.5 (15.7–17.3)	0.68 (0.63–0.72)	0.85 (0.79–0.92)
Area of residence			
Rural	23.5 (22.1–24.9)	1.12 (1.06–1.2)	1.05 (0.99–1.12)
Urban	20.7 (20.3–21.2)	1 [Reference]	1 [Reference]
Health insurance			
Yes	20.7 (20.2–21.1)	1 [Reference]	1 [Reference]
No	22.4 (19.9–24.8)	1.21 (1.11–1.33)	1.16 (1.06–1.27)
Cardiovascular disease			
Yes	29.0 (26.5–31.5)	1.45 (1.36–1.55)	1.17 (1.09–1.25)
No	20.3 (19.8–20.8)	1 [Reference]	1 [Reference]
Cancer			
Yes	26.3 (23.3–29.2)	1.13 (1.04–1.22)	1.03 (0.95–1.12)
No	20.7 (20.2–21.2)	1 [Reference]	1 [Reference]
Depressive disorder			
Yes	30.7 (29.6–31.9)	1.59 (1.51–1.66)	1.41 (1.34–1.48)
No	18.0 (17.5–18.5)	1 [Reference]	1 [Reference]
Chronic obstructive pulmonary disease			
Yes	35.8 (33.3–38.2)	1.78 (1.67–1.89)	1.33 (1.24–1.43)

Table 2 (continued)

Characteristic	Adults with COVID ($n = 120,178$)[b]	Prevalence ratio (95% CI)	
	Prevalence, % (95% CI)[c]	Model 1[d]	Model 2[e]
No	19.8 (19.4–20.3)	1 [Reference]	1 [Reference]
Asthma			
Yes	29.2 (28.0–30.4)	1.46 (1.39–1.54)	1.28 (1.21–1.35)
No	19.2 (18.7–19.7)	1 [Reference]	1 [Reference]
Kidney disease			
Yes	28.6 (25.5–31.6)	1.39 (1.27–1.52)	1.11 (1.01–1.21)
No	20.6 (20.1–21.1)	1 [Reference]	1 [Reference]

a Weighted proportions and 95% confidence intervals were calculated in consideration of the complex sampling design of the Behavioral Risk Factor Surveillance System survey

b Multiple imputation was performed. The percentage of participants with missing data was 0.8% for marital status, 0.4% for education, 0.9% for employment, 18.0% for household income, 2.3% for area of residence, 3.6% for health insurance, 0.1% for cardiovascular disease, 0.5% for cancer, 0.6% for depressive disorder, 0.4% for chronic obstructive pulmonary disease, 0.4% for asthma, and 0.4% for kidney disease

c Age adjustment was performed for the characteristics (excluding the characteristic of age group) using direct standardization based on the 2020 US Census data; the age categories used for standardization were 18 to 24 years (12.1%), 25 to 34 years (17.6%), 35 to 44 years (16.6%), 45 to 54 years (15.9%), 55 to 64 years (16.6%), 65 to 74 years (12.5%), and 75 years or older (8.7%)

d Adjusted for age groups, sex, and race/ethnicity

e Includes simultaneous adjustment for all characteristics listed

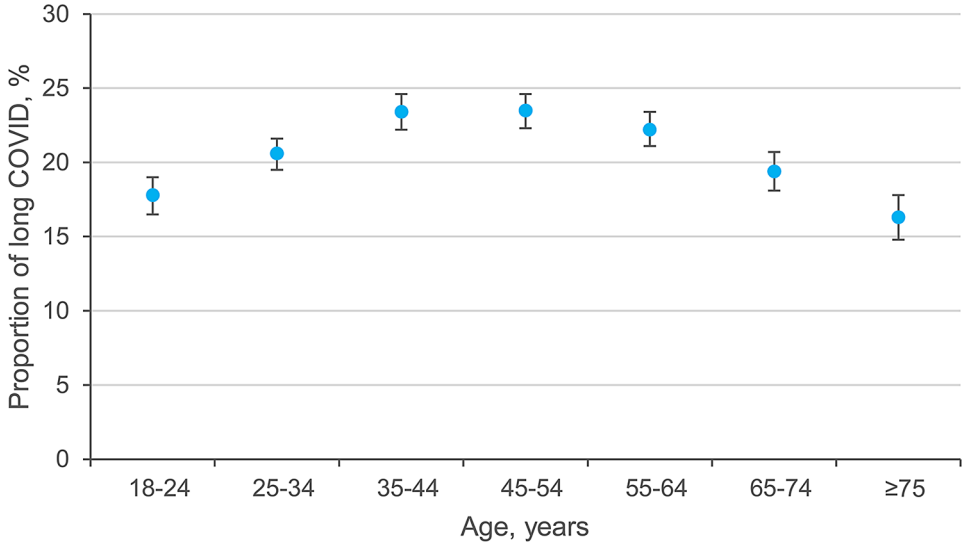

Fig. 2 The relationship between age and long COVID reporting among US adults with self-reported SARS-CoV-2 infection. Data are presented as percentages and 95% confidence intervals

another population-based survey [42]. However, conflicting reports exist regarding the relationship between race/ethnicity and long COVID [43, 44]. Our study also found that widowed, separated, or divorced marital status was associated with long COVID in the United States, a finding not previously reported. Furthermore, low socioeconomic status, including lower income, lack of health insurance, and lower educational attainment, was associated with higher rates of reporting long COVID [14, 16, 42].

Regarding comorbidities, our analysis demonstrated that the presence of various conditions, including depressive disorder, COPD, and asthma, was associated with a higher prevalence of long COVID. Notably, these associations were robust in our study, highlighting the importance of focusing on these high-risk conditions in the context of long COVID [7, 14, 16, 24]. Conversely, cardiovascular disease and kidney disease, which have not consistently been associated with long COVID in previous studies [15, 16, 24–26, 43], exhibited only slight associations in our analysis, warranting further investigation. Moreover, we found that the rate of reporting long COVID was not higher among adult cancer survivors, consistent with prior studies [24, 43].

The findings from this study carry important implications for clinical practice, particularly in risk stratification and patient management. The elevated prevalence of long COVID among middle-aged adults, women, and individuals with pre-existing conditions (e.g., depression, COPD, asthma, and cardiovascular disease) suggests that

clinicians should prioritize screening and longitudinal monitoring in these high-risk populations. Additionally, the socioeconomic disparities observed, including higher burden among uninsured and lower-income individuals, highlight the need for equitable access to post-COVID care, including rehabilitation and mental health support.

Several limitations should be acknowledged when interpreting our findings. First, our prevalence estimates are restricted to individuals with self-reported positive COVID-19 tests, potentially excluding undiagnosed cases and those with COVID-like illness who tested negative, which may lead to underestimation. Second, the cross-sectional design prevents causal inference regarding the relationships between socioeconomic factors, comorbidities, and long COVID development, while also introducing potential reverse causation. Third, symptom data relied on self-report without clinical validation, raising concerns about recall bias and subjective interpretation. Fourth, the BRFSS methodology limited participants to identifying only one primary long COVID symptom, precluding comprehensive analysis of symptom clusters or secondary manifestations. Finally, key clinical variables such as acute COVID-19 severity and medication use were not captured in the survey, representing important unmeasured confounders.

Conclusions

This nationally representative study estimates that 7.2% of US adults experienced long COVID in 2022, with higher prevalence among women, middle-aged individuals, White individuals, socioeconomically disadvantaged groups, and those with chronic conditions. These findings highlight the need for targeted public health strategies to address disparities in long COVID burden.

Abbreviations

aPR	Adjusted prevalence ratio
BRFSS	Behavioral Risk Factor Surveillance System
COPD	Chronic obstructive pulmonary disease
COVID-19	Coronavirus disease 2019
HPS	Household Pulse Survey
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology

Supplementary Information

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Supplementary Material 1

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Not applicable.

Author contributions

Study design: Juanjuan Shi, Shuangsuo Dang, and Wenjun Wang; Data collection: Juanjuan Shi, Rui Lu, and Yan Tian; Data analysis: Juanjuan Shi, Rui Lu, Yan Tian, Fengping Wu, and Xiaozhen Geng; Writing: Juanjuan Shi and Wenjun Wang; Revision: Song Zhai, Xiaoli Jia, Shuangsuo Dang, and Wenjun Wang.

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Data availability

All data are available at: https://www.cdc.gov/brfss/index.html.

Declarations

Ethics approval and consent to participate

Approval from the institutional review board was not sought for this study, as the data are publicly accessible and de-identified. Verbal consent was obtained during the telephone interview of BRFSS.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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