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Abstract

Objective. To evaluate the association of influenza vaccination in the past 12 months with Long COVID effects and clinical and sociodemographic factors.

Methods. Cross-sectional study with data from the 2022 Behavioral Risk Factor Surveillance System (BRFSS), covering 415,132 non-institutionalized U.S. adults with a confirmed COVID-19 diagnosis and influenza vaccination reported within the last 12 months. Logistic regression was conducted between influenza vaccination (exposure) and Long COVID (outcome), controlling for demographic variables, pre-existing health conditions, and socioeconomic status.

Results. Of 120,603 participants, 21.89% reported Long COVID symptoms and 42.04% had received an influenza vaccine. Findings indicate a statistically significant 13% reduction (95% CI: 1.06 - 1.20) of Long COVID among influenza-vaccinated individuals, adjusting for confounders such as healthcare access, socioeconomic and demographic factors, and chronic health conditions. Individuals with chronic health conditions, women, minority racial/ethnic groups, and adults aged 45 to 64 were more likely to report Long COVID symptoms.

Conclusions. Our study suggests that influenza vaccination may reduce Long COVID symptoms, maintaining statistical significance. Further research is needed to confirm these associations and explore strategies for addressing Long COVID challenges.

Introduction

Coronavirus disease (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged in Wuhan, China, in December 2019 and rapidly evolved into a global health emergency. The World Health Organization (WHO) declared it as a pandemic by March 2020.[1] The COVID-19 pandemic led to over 774 million cases and 7 million deaths worldwide, profoundly impacting health, economy, and global workforce, with an estimated economic loss of US$13.8 trillion by 2024.[1,2] Emergence of SARS-CoV-2 variants and reinfections has further complicated the pandemic management, with a need for ongoing

research into effective public health responses and vaccination strategies.[3,4] Amidst the direct impacts of COVID-19, the phenomenon of Long COVID, or Post-COVID-19 Conditions, has emerged, characterized by persistent multisystemic symptoms typically observed four weeks or more post-infection. This condition affects an estimated 5% to 30% of COVID-19 diagnosed population, indicating a significant subset of the population.[6,7] Long COVID poses substantial challenges to healthcare systems, economies, and society, given its potential for chronicity and the spectrum of symptoms. Long COVID symptoms can vary widely from severe fatigue, brain fog, and headaches to respiratory, cardiovascular, and neurological issues, potentially affecting daily activities and mental health. Some people with Long COVID have symptoms that are not explained by tests or easy to manage.[5] Therefore, Long COVID highlights the need for research into the complications of COVID-19, including the exploration of preventive strategies, effective management approaches, and supportive healthcare policies.

The global response to COVID-19 has heavily relied on the rapid development and deployment of vaccines. This has been pivotal in controlling the spread of the virus; however, vaccine hesitancy remains a challenge. Disparities in vaccine uptake, influenced by socioeconomic and racial factors, pose challenges to immunization efforts.[8-10] COVID-19 and influenza, while distinct in their etiology and severity, share similarities in transmission and the demographic profiles of at-risk groups.[11,12] Influenza vaccines have been a mainstay in public health for decades, with a well-established safety profile.[45] While differing in etiology and clinical severity, both illnesses prompt annual vaccination efforts due to their evolving viral strains. In this context, the potential synergistic effects of influenza with an established safety profile over decades and, nascent but promising COVID-19 vaccinations present an interesting area of investigation.[13]

Research suggests that influenza vaccination may confer indirect protection against COVID-19, highlighting the importance of widespread vaccination efforts. This indirect protective effect could, theoretically, influence the severity or presence of Long COVID symptoms by

priming the immune system to manage the virus more effectively.[14-17] This study explores the association between influenza vaccination and the presence of long-term COVID-19 effects in U.S. adults, addressing gaps in the current research and offering insights into vaccine cross-protection and public health policy.

Methods

Study Design

This cross-sectional study design used data from the 2022 Behavioral Risk Factor Surveillance System (BRFSS) dataset. BRFSS dataset is a comprehensive, nationwide survey that collects health behavior data, conducted by the Centers for Disease Control and Prevention (CDC) among the adult population in the United States. The BRFSS utilizes telephone interviews as its primary data collection method, employing a complex sampling design to ensure a representative cross-section of the U.S. adult population.

Ethical Approval

This study used publicly available de-identified public health surveillance data and was therefore not subject to IRB oversight.

Setting

The study's geographic scope encompassed a wide demographic range capturing responses from non-institutionalized adults aged 18 and older across all 50 states, the District of Columbia, and U.S. territories (Guam, Puerto Rico, and the U.S. Virgin Islands), with data collection occurring throughout 2022.

Study Population

The 2022 BRFSS survey collected responses from 415,132 individuals, representing a diverse cross-section of the non-institutionalized adult population. Participants are qualified for the study if the individuals are at least 18 years old, received a confirmed diagnosis of COVID-19 from a healthcare professional (HCP) or had a positive at-home test result, and completed items in the questionnaire regarding their influenza vaccination status in the last 12 months. To

ensure relevance to the study's objectives, participants who did not respond or were unsure of the answer to the questions concerning COVID-19 test, influenza vaccination status, prolonged COVID-19 symptoms, and essential survey items, including but not limited to, demographic profiles, and additional significant covariates were excluded. However, an 'unknown' income category was included to accommodate responses with over 10% missingness in this variable. After considering all the inclusion and exclusion criterion, a total of 120,603 respondents were included in the final sample.

Measures

Long COVID, officially recognized as 'post-COVID-19 Conditions' encompass a wide array of persistent symptoms manifesting after the initial SARS-CoV-2 infection, often persisting beyond four weeks post-infection and characterized by fatigue, cognitive dysfunction, and various multisystemic manifestation.[7] BRFSS survey collected self-reported data on symptoms persisting "3 months or longer" post-COVID-19 infection, consistent with WHO's definition of Long COVID.[6] The survey specifically queries whether symptoms developed only after the COVID-19 infection, distinguishing Long COVID symptoms from those of pre-existing conditions or other illnesses. The primary aim is to investigate the protective effect of influenza vaccination against Long COVID, with vaccination status within the previous 12 months serving as the exposure variable and the presence of Long COVID symptoms as the outcome variable.

Given the similarities in transmission and risk groups between COVID-19 and influenza, we explore the potential protective effect of the influenza vaccine against Long COVID.[20] The BRFSS survey collected data concerning individuals' vaccination status within the previous 12 months, either through nasal spray or an injection in the arm. Participants' vaccination status is categorized into 'Yes' for those who received the vaccine and 'No' for those who did not, allowing for a clear delineation of exposure groups.

Participants were categorized into sub-groups (18 to 44, 45 to 64, and 65 or older years) primarily based on age for detailed stratified analyses. Other demographic and health-related

variables including gender (Male/Female), race/ethnicity (White, Non-Hispanic; Black, Non-Hispanic; Hispanic; Other Race), and education levels (ranging from 'Did not graduate High School' to 'Graduated from College/Technical School') were controlled for in the analysis. Income levels were divided into Less than $50,000; $50,000 to $99,999; $100,000 or more, with a provision for Missing data. Access to healthcare was assessed as ability to afford a doctor visit, and smoking status was categorized based on history and intensity of smoking. The CDC has identified several underlying medical conditions as risk factors for severe illness from COVID-19. By categorizing participants based on the presence of these pre-existing health conditions, our study aims to provide a better understanding of their impact on Long COVID.[28,29] Chronic health conditions, including diabetes, heart disease, stroke, asthma (current, former, and never), lung disease, cancers (excluding non-melanoma skin cancers), and renal disease, were controlled to understand their influence on long COVID outcomes.

Data Collection

Data was collected via the BRFSS, employing a multistage, random-digit-dialing methodology for landlines and cell phones to ensure a representative sample of the U.S. adult population.

Statistical Analysis

Univariate analyses were used to explore descriptive statistics (frequencies and percentages for categorical variables, means, and standard deviations for continuous variables) and characterize the study population across all variables of interest, including age, gender, race/ethnicity, education, income level, healthcare access, smoking status, and pre-existing health conditions.

Bivariate analyses were used to assess the relationship between influenza vaccination status and the reporting of Long COVID symptoms. Prevalence odds ratios (PORs) were calculated to measure the strength of association between not receiving the flu vaccine and reporting Long COVID symptoms, adjusted for demographic factors including age, gender,

race/ethnicity, education level, income, healthcare accessibility, smoking status, and the presence of chronic health conditions. Similarly, bivariate analysis also extended to explore the influence of demographic characteristics and health behaviors on the uptake of influenza vaccination.

To account for potential confounding factors such as age, gender, race/ethnicity, education, income level, and presence of chronic health conditions, a weighted multivariate logistic regression model was utilized. The presence of a statistically significant interaction between flu vaccination status and age prompted the inclusion of age as a covariate in subsequent models. Based on these p-values, variables with insufficient evidence to assert a meaningful association were excluded, proceeding with a reduced final model for the stratified analyses. The adequacy of the model fit was assessed using the R-squared value. Given the potential biases associated with self-reported data, our statistical analysis incorporated the BRFSS's complex sampling design adjustments to mitigate these effects and enhance data representativeness. The selection of covariates for inclusion in the model was based on their presumed relationship with the outcome, as informed by existing literature and the observed associations in the bivariate analyses.[18,20] Statistical analyses were conducted using SAS Studio 3.82 (SAS Institute, Cary, NC).

Results

Our study analyzed data from 120,603 U.S. adult participants who tested positive for COVID-19 test by an HCP or self-reported using an at-home test without HCP confirmation (Table 1). Of these participants, 26,638 (21.89%) reported experiencing long COVID symptoms and 57,894 (42.04%) reported influenza vaccination. The gender distribution was relatively balanced with slight female majority (53.42%). Majority of the participants were aged 18 to 45 years (53.08%), followed by those aged 45 to 65 years (31.36%), and those 65 or older (15.56%). Most participants are White, Non-Hispanic (59.33%), followed by Hispanic (19.62%), Black, Non-Hispanic (10.66%), and ‘Other Race’ (10.39%). A similar proportion of participants

attended some college or technical school (32.21%) or graduated from college or technical school (32.25%), while smaller proportions did not graduate high school (9.12%) or only graduated high school (26.42%). Participants were evenly distributed across income categories All percentages are adjusted percentages. Additional demographic information can be found in Table 1.

Based on results from Table-2, individuals who did not receive the flu vaccine had a 16% higher likelihood of reporting long COVID symptoms compared to those who were vaccinated (95% CI: 1.09-1.22). Age-specific analyses indicated that adults aged 45-64 had a 12% higher likelihood of reporting long COVID symptoms compared to those aged 18-44 (95% CI: 1.05-1.19), while those 65 years and older showed 15% lower odds of experiencing these symptoms (95% CI: 0.79-0.92). Gender differences revealed that males had 40% lower odds of reporting long COVID symptoms compared to females (95% CI: 0.57- 0.63). Individuals unable to afford a doctor's visit or with a smoking history (current smokers and ex-smokers) demonstrated higher odds of reporting long COVID symptoms, as did individuals with less than a high school education and an annual income of less than $50,000. Furthermore, the presence of pre-existing conditions such as asthma and lung disease significantly increased the likelihood of experiencing prolonged symptoms.

Results from Table 3 revealed that individuals not vaccinated against the flu had 13% higher odds of reporting long COVID symptoms (95% CI: 1.06 - 1.20). Participants aged 45 to 64 years old showed 9% higher odds, and those aged 65 or older demonstrated 22% lower odds of reporting Long COVID symptoms compared to the 18-44 age group (95% CI: 0.70 - 0.85). Males and minority races (Black, Non-Hispanic; Other Races) reported lower odds of reporting long COVID symptoms. Education and income levels significantly influenced the likelihood of reporting long COVID symptoms; individuals with some college education had higher odds of symptoms compared to college graduates, and those earning less than $100,000 annually reported higher odds of reporting symptoms compared to individuals earning $100,000

or more. The inability to afford a doctor visit and smoking status significantly affected long COVID outcomes. Chronic conditions significantly increased the odds of reporting symptoms, with asthma, lung disease, diabetes, and heart disease also linked to higher odds of reporting long COVID symptoms.

Table 4 interpretation showed the relationship between various characteristics and reported long COVID symptoms stratified across three different age group categories. In the 18-44 and 45-64 age groups, unvaccinated individuals demonstrated increased odds of long COVID symptoms, an effect not observed in those aged 65 and older. Gender analysis revealed that males across all age groups had significantly lower odds of reporting long COVID symptoms compared to females, with OR ranging from 0.59 to 0.62 across various age groups, all with 95% confidence intervals from 0.51 to 0.68 and p-values below 0.0001. Socioeconomic status and health behaviors significantly affected Long COVID; lower income and lack of healthcare access exhibited higher odds, especially among those aged 18-44 years. Individuals earning less than $50,000 annually in the 65+ age group showed higher susceptibility to long COVID symptoms. The ability to afford a doctor visit significantly influenced the reporting of long COVID symptoms in younger individuals. Lifestyle factors such as smoking and chronic conditions such as asthma and lung disease significantly increased the risk of long COVID symptoms across various age groups.

Discussion

In our study, we examined the association between influenza vaccination and persistence of symptoms associated with Long COVID among U.S. adults. Eligible study participants were adults aged 18 and over, confirmed COVID-19 diagnosis, and reported influenza vaccination status in the last 12 months. Our analysis revealed that individuals who had received influenza vaccine showed a 16% decrease in the likelihood of experiencing long COVID symptoms compared to those who were not vaccinated in the last 12 months. After adjusting for sociodemographic variables, the adjusted prevalence odds ratio (OR) was slightly

reduced to 13%, indicating a maintained but modest protective effect of the influenza vaccine against long COVID symptoms. This finding suggests a protective effect of the influenza vaccine against the chronic sequelae of COVID-19, potentially attributable to an enhanced immune defense mechanism.[16] The mechanisms underlying this protective association may involve the vaccine's ability to prime the immune system, thereby offering a broadened defense against not only influenza but possibly other viral pathogens, including SARS-CoV-2.[17] This hypothesis is supported by literature revealing that influenza vaccination was associated with a reduced risk of SARS-CoV-2 infection and hospitalization among COVID-19 patients, emphasizing the potential role of influenza vaccination in mitigating COVID-19 risks and severity.[14-17] In addition, current literature on vaccine-induced cross-protection indicate that vaccination can sometimes confer broader immune benefits beyond the specific target pathogen.[21,22]

The study specifically examined the interaction between age and influenza vaccination on the prevalence of long COVID, revealing that the vaccine's protective effect was consistent across most age groups. However, adults aged 45-64 showed a marginally higher likelihood of reporting long COVID symptoms post-vaccination, possibly due to their increased susceptibility to COVID-19 complications. Interestingly, individuals aged 65 and above showed unexpectedly lower prevalence of long COVID symptoms. This finding contrasts with current understanding of COVID-19 outcomes, where older populations is typically associated with an increased risk of acute COVID-19 severity and mortality.[23,24] This may be influenced by age-related altered immune responses, such as immunosenescence, which potentially modifies the progression of post-acute COVID-19 effects or behaviors like increased vaccination uptake and adherence to preventive health measures in 65 and above age group.[25,26] The interaction between age and influenza vaccination illustrates the complexity of vaccine responses in mitigating long COVID symptoms across different demographics.

In our analysis, gender emerged as a significant factor in the prevalence of long COVID symptoms, with males exhibiting a notably lower likelihood of reporting these symptoms

compared to females. The disparity might have been influenced by biological and social differences in the pathogenesis of the disease with a heightened inflammatory response during the acute phase of COVID-19 in females, alongside variations in IgG antibody production levels.[27-31]

In our study, individuals from lower-income groups exhibited a higher prevalence of long COVID, likely due to factors such as reduced healthcare access and increased occupational exposure.[46] Similarly, lower educational attainment was associated with an increased risk of prolonged symptoms, potentially reflecting gaps in health literacy and resource access. The relationship between education and health outcomes has been extensively documented, indicating that higher education levels often correlate with higher income, better health behaviors, and access to quality healthcare services conducive to recovery and prevention.[32] These findings emphasize the necessity for public health interventions tailored to address socioeconomic factors, with efforts focused on improving access to healthcare, enhancing public health messaging, and supporting socioeconomically disadvantaged communities.[33]

Results from our study indicated that Black, Non-Hispanic individuals, and those of other Races exhibited lower odds of reporting long COVID symptoms compared to their White, Non-Hispanic counterparts. Prior research highlights the complex relationship between race, socioeconomic factors, and health disparities, often revealing that minority populations face higher risks of adverse health outcomes.[34-36] However, the observed lower incidence of long COVID symptoms among Black, Non-Hispanic and Other Race groups could be influenced by underreporting, differential access to healthcare, or variations in the social determinants of health that affect disease reporting and management.[36] Smoking is seen as a significant factor exacerbating COVID-19 severity across all age groups, highlighting the importance of integrating smoking cessation into comprehensive COVID-19 mitigation efforts.[41]

The correlation between chronic health conditions and the persistence of Long COVID symptoms was pronounced in our study, aligning with existing theories that pre-existing health

conditions may amplify the severity of COVID-19, thereby increasing the likelihood of enduring symptoms.[42] Individuals with chronic diseases are more likely to receive influenza vaccinations due to increased health awareness and the emphasis placed by HCPs on vaccinations as preventive measures against severe viral infection complications.[38] Targeted public health campaigns and medical guidelines further advocate for vaccine uptake as essential to the health management of those with chronic conditions.[38-40] Potential mechanisms underpinning this association could involve chronic inflammation, dysregulation of the immune system, or the overarching burden of managing chronic illnesses over time, complicating the trajectory towards the outcome of COVID-19 infection.[43,44] The complexity of Long COVID as a multifaceted syndrome could have been influenced by both the viral pathology and the host's pre-existing health status, highlighting the necessity for tailored management strategies in individuals with chronic conditions.

Limitations

This study leverages robust, comprehensive BRFSS dataset that covers U.S. adult population, enhancing the representativeness and reliability of our findings. The large sample size allows for detailed subgroup analyses, to understand the differential impacts across various demographic groups, thereby contributing significant insights into public health strategies.

However, the study's reliance on cross-sectional data from the BRFSS precludes the establishment of causality in the observed relationships. In addition, the BRFSS methodology systematically excludes individuals in institutional settings such as nursing homes and prisons — environments known for higher COVID-19 transmission rates, underestimating true association between Long COVID and flu vaccination in last 12 months.

Additional constraint includes reliance on participants' self-reported data, which raises concerns about the accuracy of recall regarding symptoms, their duration, and the specifics of vaccinations received, which may introduce response bias. Consequently, this could lead to information bias due to imprecise measurement of key constructs, thus potentially simplifying

the intricate relationship between Long COVID and influenza vaccination status. Finally, the BRFSS survey captures data relevant to the U.S. population, limiting the generalizability of our results to other countries or healthcare systems, emphasizing the need for caution when extrapolating our conclusions to global contexts.

Public Health Significance

Our study highlights the need for strategic public health interventions and policy reforms aimed at enhancing influenza vaccination rates. This approach serves a triple role: it directly prevents influenza, potentially mitigates the impact of Long COVID through a cross-protective effect and supports broader COVID-19 vaccination efforts.

The study findings advocate for a health framework that not only reinforces existing defenses against Long COVID and influenza but also advances healthcare equity and the accessibility of vaccines. This approach acknowledges the importance of addressing disparities based on gender, educational status, or socioeconomic status and calls for integrated healthcare policies, ensuring equitable access to treatment and resources for all segments of the population. Future research should assess the effectiveness of holistic public health strategies that combine policy adjustments, public education, and clinical practices tailored to the unique challenges of Long COVID.

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Table 1. Description of the Study Population, BRFSS 2022

Characteristics	N (n= 120,603)	(Weighted% ± Standard Error)
Long COVID		
Yes	26,638	21.9% ± 0.2
No	93,965	78.1% ± 0.2
Flu Vaccine in last 12 months		
Yes	57,894	42.0% ± 0.3
No	62,709	58.0% ± 0.3
Age		
18 to 44	46,937	53.1% ± 0.3
45 to 64	43,062	31.4% ± 0.3
65 or older	30,604	15.6% ± 0.2
Gender		
Male	55,333	46.6% ± 0.3
Female	65,270	53.4% ± 0.3
Race/Ethnicity		
White, Non-Hispanic	88,829	59.3% ± 0.3
Black, Non-Hispanic	8,877	10.7% ± 0.2
Hispanic	13,881	19.6% ± 0.3
Other Race	9,016	10.4% ± 0.2
Education		
Did not graduate High School	5,886	9.1% ± 0.2
Graduated High School	27,722	26.4% ± 0.3
Attended College/Technical School	34,156	32.2% ± 0.3
Graduated from College/Technical School	52,472	32.3% ± 0.3
Income		
Less than $50,000	36,700	31.1% ± 0.3
$50,000 to $99,999	32,794	25.3% ± 0.2
$100,000 or more	32,646	27.1% ± 0.3
Missing	18,463	16.5% ± 0.2
Afford Doctor Visit		
Yes	108,884	88.0% ± 0.2
No	11,419	12.0% ± 0.2
Smoking		
Current smoker, 20+ Pack Years	4,366	3.1% ± 0.1
Former smoker, 20+ Pack Years, quit < 15 years	3,927	2.6% ± 0.1
All other current and former smokers	36,193	28.3% ± 0.3
Never smoker	75,365	66.0% ± 0.3
Diabetes		
Yes	15,820	11.7% ± 0.2
No	100,528	88.4% ± 0.2
Heart Disease		
Yes	9,394	5.7% ± 0.1
No	110,194	94.3% ± 0.1
Stroke		
Yes	4,278	3.0% ± 0.1
No	116,024	97.0% ± 0.1
Asthma		
Current	14,427	11.6% ± 0.2
Former	5,907	5.5% ± 0.1
Never	99,298	82.9% ± 0.2
Lung Disease		
Yes	8,754	6.1% ± 0.1
No	111,391	93.9% ± 0.1
Cancers (excluding non-melanoma skin cancers)		
Yes	11,798	7.1% ± 0.1
No	108,365	92.9% ± 0.1
Renal Disease		
Yes	5,144	3.4% ± 0.1
No	115,075	96.6% ± 0.1

Abbreviations: N=frequency, COVD-19=Coronavirus disease 2019, BRFSS=Behavioral Risk Factor Surveillance System.

Table 2. Long COVID and Associated Variables, by Baseline Characteristics, Among Respondents Who Tested COVID-19 Positive, BRFSS 2022 (Outcome)

Characteristics	Reported Long COVID (Weighted%) (n= 26,638)	Did not report Long COVID (Weighted%) (n= 93,965)	Prevalence Odds Ratio (95% CI)	p-value
Received Flu Vaccine				<.0001
Yes	11,946 (39.3%)	45,948 (42.8%)	Reference	
No	14,692 (60.7%)	48,017 (57.2%)	1.16 (1.09-1.22)	
Age				<.0001
18 to 44	10,217 (52.6%)	36,720 (53.2%)	Reference	
45 to 64	10,500 (33.8%)	32,562 (30.7%)	1.12 (1.05 - 1.19)	
65 or older	5,921 (13.6%)	24,683 (16.1%)	0.85 (0.79 - 0.92)	
Gender				<.0001
Male	9,601 (36.8%)	45,732 (49.3%)	0.60 (0.57- 0.63)	
Female	17,037 (63.2%)	48,233 (50.7%)	Reference	
Race/Ethnicity				0.0025
White, Non-Hispanic	19,661 (60.5%)	69,168 (59.0%)	Reference	
Black, Non-Hispanic	1,756 (9.9%)	7,121 (10.9%)	0.89 (0.81 - 0.98)	
Hispanic	3,241 (20.3%)	10,640 (19.4%)	1.02 (0.94 - 1.11)	
Other Race	1,980 (9.3%)	7,036 (10.7%)	0.84 (0.75 - 0.94)	
Education				<.0001
Not High School		4,462 (8.9%)	1.40 (1.23 – 1.59)	
Graduate	1,424 (10.1%)			
Graduated High School	6,382 (26.1%)	21,340 (26.5%)	1.21 (1.13 – 1.30)	
Attended College	8,797 (36.5%)	25,359 (31.0%)	1.45 (1.36 – 1.54)	
College Graduate	9,957 (27.3%)	42,515 (33.6%)	Reference	
Income				<.0001
Less than $50,000	9,725 (36.2%)	26,975 (29.7%)	1.56 (1.45 - 1.68)	
$50,000 to $99,999	7,290 (26.7%)	25,504 (24.9%)	1.37 (1.27 - 1.48)	
$100,000 or more	5,887 (22.3%)	26,759 (28.5%)	Reference	
Missing	3,736 (14.9%)	14,727 (16.9%)	1.13 (1.03 - 1.24)	
Afford Doctor Visit				<.0001
Yes	22,370 (80.6%)	86,514 (90.1%)	Reference	
No	4,196 (19.4%)	7,223 (9.9%)	2.19 (2.02 - 2.37)	
Smoking				<.0001
Current smoker (20+ PY)	1,279 (4.0%)	3,087 (2.8%)	1.59 (1.40 - 1.80)	
Ex-Smoker (20+ PY)#	1,096 (3.3%)	2,831 (2.4%)	1.49 (1.30 - 1.72)	
All other smokers	8,809 (31.6%)	27,384 (27.3%)	1.28 (1.20 - 1.36)	
Never smoker	15,307 (61.0%)	60,058 (67.4%)	Reference	
Diabetes				<.0001
Yes	4,144 (13.8%)	11,676 (11.1%)	1.29 (1.19 - 1.39)	
No	21,298 (86.2%)	79,230 (88.9%)	Reference	
Heart Disease				<.0001
Yes	2,631 (7.3%)	6,763 (5.3%)	1.42 (1.29 - 1.55)	
No	23,727 (92.7%)	86,467 (94.7%)	Reference	
Stroke				<.0001
Yes	1,256 (4.1%)	3,022 (2.7%)	1.52 (1.33 - 1.74)	
No	25,275 (95.9%)	90,749 (97.3%)	Reference	
Asthma				<.0001
Current	4,896 (17.6%)	9,531 (9.9%)	1.96 (1.82 - 2.12)	
Former	1,401 (5.9%)	4,506 (5.4%)	1.20 (1.07 - 1.35)	
Never	20,031 (76.5%)	79,267 (84.6%)	Reference	
Lung Disease				<.0001
Yes	3,102 (10.1%)	5,652 (5.0%)	2.16 (1.97 - 2.37)	
No	23,380 (89.9%)	88,011 (95.0%)	Reference	
Cancers (excluding NMSC)				0.0062
Yes	2,774 (7.9%)	9,024 (6.9%)	1.14 (1.04 - 1.26)	
No	23,748 (92.1%)	84,617 (93.1%)	Reference	
Renal Disease				<.0001
Yes	1,485 (4.6%)	3,659 (3.1%)	1.50 (1.32 - 1.69)	
No	25,039 (95.4%)	90,036 (96.9%)	Reference	

Abbreviations: N=frequency, COVD-19=Coronavirus disease 2019, CI=Confidence Interval, NMSC= Nonmelanoma Skin Cancer, PY=Pack-Years #quit smoking <15 years, BRFSS=Behavioral Risk Factor Surveillance System.

Table 3. Adjusted Multivariate Logistic Regression: Impact of Sociodemographic Variables On Those Who Tested COVID-19 Positive, BRFSS 2022 (n= 120,603)

Characteristics	Crude OR (95% CI)	Prevalence AOR (95% CI)
Received Flu Vaccine		
Yes	Reference	Reference
No	1.16 (1.09-1.22)	1.13 (1.06 - 1.20)
Age		
18 to 44	Reference	Reference
45 to 64	1.12 (1.05 - 1.19)	1.09 (1.01 - 1.16)
65 or older	0.85 (0.79 - 0.92)	0.78 (0.70 - 0.85)
Gender		
Male	0.60 (0.57- 0.63)	0.61 (0.57 - 0.64)
Female	Reference	Reference
Race/Ethnicity		
White, Non-Hispanic	Reference	Reference
Black, Non-Hispanic	0.89 (0.81 - 0.98)	0.82 (0.74 - 0.91)
Hispanic	1.02 (0.94 - 1.11)	0.97 (0.88 - 1.07)
Other Race	0.84 (0.75 - 0.94)	0.85 (0.75 - 0.97)
Education		
Not High School Graduate	1.40 (1.23 – 1.59)	1.06 (0.92 - 1.22)
Graduated High School	1.21 (1.13 – 1.30)	1.06 (0.98-1.14)
Attended College	1.45 (1.36 – 1.54)	1.26 (1.17 - 1.35)
College Graduate	Reference	Reference
Income		
Less than $50,000	1.56 (1.45 - 1.68)	1.16 (1.06 - 1.27)
$50,000 to $99,999	1.37 (1.27 - 1.48)	1.20 (1.10 - 1.30)
$100,000 or more	Reference	Reference
Missing	1.13 (1.03 - 1.24)	0.99 (0.89 - 1.10)
Afford Doctor Visit		
Yes	Reference	Reference
No	2.19 (2.02 - 2.37)	1.87 (1.71 - 2.05)
Smoking		
Current smoker (20+ PY)	1.59 (1.40 - 1.80)	1.19 (1.02 - 1.39)
Ex-Smoker (20+ PY)#	1.49 (1.30 - 1.72)	1.32 (1.13 - 1.54)
All other smokers	1.28 (1.20 - 1.36)	1.23 (1.15 - 1.31)
Never smoker	Reference	Reference
Diabetes		
Yes	1.29 (1.19 - 1.39)	1.19 (1.08 - 1.30)
No	Reference	Reference
Heart Disease		
Yes	1.42 (1.29 - 1.55)	1.20 (1.07 - 1.34)
No	Reference	Reference
Stroke		
Yes	1.52 (1.33 - 1.74)	1.13 (0.96 - 1.33)
No	Reference	Reference
Asthma		
Current	1.96 (1.82 - 2.12)	1.57 (1.44 - 1.71)
Former	1.20 (1.07 - 1.35)	1.17 (1.03 - 1.32)
Never	Reference	Reference
Lung Disease		
Yes	2.16 (1.97 - 2.37)	1.56 (1.38 - 1.76)
No	Reference	Reference
Cancers (excluding NMSC)		
Yes	1.14 (1.04 - 1.26)	1.04 (0.92 - 1.16)
No	Reference	Reference
Renal Disease		
Yes	1.50 (1.32 - 1.69)	1.19 (1.03 - 1.37)
No	Reference	Reference

Abbreviations: N=frequency, COVD-19=Coronavirus disease 2019, CI=Confidence Interval, NMSC= Nonmelanoma Skin Cancer, PY=Pack-Years #quit smoking <15 year, AOR= Adjusted Odds Ratio, OR= Odds Ratio, BRFSS=Behavioral Risk Factor Surveillance System.

Table 4. Impact of Sociodemographic Variables and Long COVID Stratified by Age Groups, On Those Who Tested COVID-19 Positive, BRFSS 2022 (n= 120,603)

Characteristics	Crude OR (95% CI)	Age 18-44 yrs Prevalence AOR (95%CI)	Age 45-64 yrs Prevalence AOR (95%CI)	Age >65 yrs Prevalence AOR (95%CI)
Received Flu Vaccine				
Yes	Reference	Reference	Reference	Reference
No	1.16 (1.09-1.22)	1.17 (1.07-1.28)	1.14 (1.04-1.26)	0.95 (0.83-1.10)
Gender				
Male	0.60 (0.57-0.63)	0.59 (0.54-0.65)	0.62 (0.56-0.68)	0.59 (0.51-0.67)
Female	Reference	Reference	Reference	Reference
Race/Ethnicity				
White, Non-Hispanic	Reference	Reference	Reference	Reference
Black, Non-Hispanic	0.89 (0.81-0.98)	0.81 (0.70-0.94)	0.87 (0.74-1.02)	0.72 (0.55-0.93)
Hispanic	1.02 (0.94-1.11)	0.99 (0.88-1.12)	0.99 (0.84-1.17)	0.74 (0.53-1.03)
Other Race	0.84 (0.75-0.94)	0.82 (0.70-0.95)	0.86 (0.68-1.08)	1.12 (0.74-1.72)
Education				
Not High School Graduate	1.40 (1.23-1.59)	1.14 (0.92-1.42)	1.04 (0.84-1.29)	0.98 (0.70-1.36)
Graduated High School	1.21 (1.13-1.30)	1.06 (0.95-1.18)	1.05 (0.92-1.19)	1.09 (0.91-1.31)
Attended College	1.45 (1.36-1.54)	1.31 (1.18-1.45)	1.25 (1.11-1.40)	1.11 (0.95-1.30)
College Graduate	Reference	Reference	Reference	Reference
Income				
Less than $50,000	1.56 (1.45-1.68)	1.10 (0.97-1.26)	1.22 (1.06-1.41)	1.33 (1.08-1.63)
$50,000 to $99,999	1.37 (1.27-1.48)	1.22 (1.08-1.38)	1.11 (0.98-1.26)	1.38 (1.11-1.71)
$100,000 or more	Reference	Reference	Reference	Reference
Missing	1.13 (1.03-1.24)	0.92 (0.79-1.08)	1.07 (0.92-1.25)	1.15 (0.92-1.44)
Afford Doctor Visit				
Yes	Reference	Reference	Reference	Reference
No	2.19 (2.02-2.37)	2.00 (1.79-2.23)	1.71 (1.47-1.98)	1.52 (1.03-2.24)
Smoking				
Current smoker (20+ PY)	1.59 (1.40-1.80)	1.60 (1.20-2.13)	1.11 (0.92-1.35)	0.90 (0.59-1.39)
Ex-Smoker (20+ PY)#	1.49 (1.30-1.72)	1.09 (0.71-1.69)	1.31 (1.07-1.60)	1.40 (1.06-1.86)
All other smokers	1.28 (1.20-1.36)	1.23 (1.12-1.35)	1.20 (1.08-1.34)	1.25 (1.08-1.44)
Never smoker	Reference	Reference	Reference	Reference
Diabetes				
Yes	1.29 (1.19-1.39)	1.13 (0.92-1.38)	1.29 (1.13-1.47)	1.12 (0.96-1.30)
No	Reference	Reference	Reference	Reference
Heart Disease				
Yes	1.42 (1.29-1.55)	1.19 (0.87-1.63)	1.13 (0.97-1.33)	1.32 (1.12-1.56)
No	Reference	Reference	Reference	Reference
Asthma				
Current	1.96 (1.82-2.12)	1.51 (1.34-1.71)	1.68 (1.47-1.92)	1.54 (1.26-1.88)
Former	1.20 (1.07-1.35)	1.32 (1.12-1.55)	1.00 (0.81-1.22)	0.87 (0.60-1.27)
Never	Reference	Reference	Reference	Reference
Lung Disease				
Yes	2.16 (1.97-2.37)	1.34 (1.07-1.68)	1.62 (1.36-1.93)	1.74 (1.39-2.18)
No	Reference	Reference	Reference	Reference
Renal Disease				
Yes	1.50 (1.32-1.69)	1.21 (0.86-1.71)	1.16 (0.94-1.44)	1.25 (1.03-1.51)
No	Reference	Reference	Reference	Reference

Abbreviations: N=frequency, COVD-19=Coronavirus disease 2019, CI=Confidence Interval, NMSC= Nonmelanoma Skin Cancer, PY=Pack-Years #quit smoking <15 year, AOR= Adjusted Odds Ratio, OR= Odds Ratio, BRFSS=Behavioral Risk Factor Surveillance System.