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RESEARCH ARTICLE

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Occupational and industry prevalence of new long-term symptoms within American Red Cross blood donors with and without history of SARS-CoV-2 infection

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Abstract

Purpose: Limited information is known about the burden of Long COVID by occupation and industry. This study compares the occurrence of self-reported new long-term symptoms lasting 4 weeks or longer among blood donors with and without prior SARS-CoV-2 infection by occupation and industry.

Methods: The American Red Cross invited blood donors 18 years and older who donated during May 4–December 31, 2021 to participate in online surveys. New long-term symptoms lasting 4 weeks or longer were assessed by self-reported occurrence of any of 35 symptoms since March 2020. SARS-CoV-2 infection status was determined by serological testing and self-report. We describe the prevalence of new long-term symptoms by SARS-CoV-2 infection status. We calculate the difference in reported new long-term symptoms by SARS-CoV-2 infection status within occupation and industry categories.

Results: Data were collected from 27,907 employed adults – 9763 were previously infected and 18,234 were never infected with SARS-CoV-2. New long-term symptoms were more prevalent among those previously infected compared to the never-infected respondents (45% vs 24%, $p < 0.05$). Among all respondents, new long-term symptoms by occupation ranged from 26% (installation, maintenance, and repair) to 41% (healthcare support) and by industry ranged from 26% (mining) to 55% (accommodation and food services). New long-term neurological and other symptoms were commonly reported by those previously infected with SARS-CoV-2.

Discussion: New long-term symptoms are more prevalent among certain occupation and industry groups, which likely reflects differential exposure to SARS-CoV-2. These findings highlight potential need for workplace accommodations in a variety of occupational settings to address new long-term symptoms.

KEYWORDS

COVID-19, industry, Long COVID, occupation, Post-COVID Conditions, SARS-CoV-2

1 | INTRODUCTION

Previous studies have reported the difference in prevalence of SARS-CoV-2 infection by occupation and industry group.[1,2] Workers whose jobs were deemed essential during the COVID-19 pandemic, those in occupations requiring in-person contact, and those with poor COVID-19 workplace mitigation measures have increased risk for SARS-CoV-2 infection.[1,3] These studies have focused on risk factors for infection and acute outcomes. Beyond understanding the risk factors and immediate impacts of acute SARS-CoV-2 infections to tailor industry-specific safety policies, a deeper comprehension of the long-term consequences of COVID-19 is crucial for preventing short- and longer-term impacts to the workplace, empowering employers to implement supportive measures for their employees' sustained health and productivity.

Longer-term consequences of SARS-CoV-2 infection are referred to as Long COVID. Long COVID symptoms include a range of physical and mental health consequences, present 4 weeks or longer after SARS-CoV-2 infection.[4] These long-term symptoms may impact both workers and employers. A report using data from the U.S. Census Bureau's Household Pulse Survey in June 2022 found that Long COVID among adults previously infected with SARS-CoV-2 was responsible for up to 15% of the labor shortage in the United States.[5] In 2022, 6.9% of U.S. adults reported ever experiencing Long COVID symptoms lasting 3 months or longer, and 1 in 4 U.S. adults with Long COVID reported significant activity limitation.[6,7] In a study from the United Kingdom, workers in public facing occupations and industries, such as healthcare, retail, teaching and education, and social care, had the highest likelihood of Long COVID, which largely reflects higher exposure to SARS-COV-2 infection.[8] Among workers with paid COVID-19 workers compensation claims, those in public administration and manufacturing had more than 2 times the odds of reporting Long COVID compared to workers in healthcare and social assistance, after adjusting for sociodemographic characteristics and variant wave.[9] Previous studies analyzing the prevalence of new long-term symptoms by occupation or industry have not included a comparison group of adults without a history of COVID-19, which is needed to understand the background prevalence of new long-term symptoms in the absence of COVID-19.

We examined the prevalence of self-reported new long-term symptoms lasting 4 weeks or longer since March 2020 by occupation and industry and SARS-CoV-2 infection status among U.S. blood donors. Few studies have reported the prevalence or risk of Long COVID symptoms by occupation or industry and none have examined these estimates among working adults in the United States. This study aims to understand whether the proportion and burden of these new long-term symptoms differs by occupation and industry in the United States. Examining the prevalence of new long-term symptoms among those previously and never infected with SARS-CoV-2 can provide context for how SARS-CoV-2 infection may influence the long-term health of the U.S. workforce.

2 | METHODS

2.1 | Overview

This analysis utilized surveys and SARS-CoV-2 serologic testing from American Red Cross (ARC) blood donors 18 years and older who donated between May 2021 and December 2021. All U.S. blood donations during May–June 2021 and a geographical subset during July–December 2021 underwent serologic testing for anti-Spike (anti-S) and anti-nucleocapsid (anti-N) antibodies. Blood donors with blood donation serologic testing during this time period received an occupations survey approximately 2 weeks after their blood donation, and then a long-term symptom survey during February to April 2022. Blood donors with serologic testing and responses to both surveys were included in this analysis. The prevalence of new long-term symptoms among previously infected and never infected individuals was compared by industry and occupation group.

2.2 | Occupations survey and categorization of industry and occupation

The occupations survey collected detailed information on donors' occupation and industry. Occupation was defined as an individual's job whereas industry was defined as the type of business in which an individual works.[10] Respondents self-reported the occupation and industry they worked in from March 2020 until their most recent blood donation using free text. Our final analytic sample included employed ARC blood donors. Responses were coded to standard 2010 Census occupation codes and 2012 Census industry codes using the National Institute for Occupational Safety and Health Industry and Occupation Computerized Coding System. The occupation codes were further grouped into 23 categories developed by the National Center for Health Statistics (Supplemental Materials).[1,2,11] Additional information about those invited and who responded to the occupations survey are detailed in our initial report from this data source.[1]

2.3 | Long-term symptoms survey

Those invited to complete the occupations survey were eligible to receive the long-term symptoms survey. The long-term symptoms survey collected information about new long-term symptoms lasting 4 weeks or longer since the start of the pandemic in March 2020 (Supplemental Materials).[12] Respondents were asked to report whether they experienced one or more of 35 symptoms lasting 4 weeks or longer that they had not experienced before March 2020. Symptoms were further categorized for analysis by bodily system – neurological, gastrointestinal, respiratory and cardiac, mental health, and "other" (Supplemental Materials). Data on the start and end dates of these new long-term symptoms were not collected. Additional information was not collected from previously infected respondents

to determine whether the symptoms were present before the SARS-CoV-2 infection.

During the long-term symptoms survey, respondents also self-reported their age, sex, race, Hispanic ethnicity, zip code of residence, and pre-existing chronic conditions before March 2020. Pre-existing chronic conditions included report of chronic pain, anxiety, depression, chronic headaches, stroke, kidney disease, liver disease, heart disease, lung disease, high blood pressure, diabetes, immune disorder, and cancer. Self-reported prior SARS-CoV-2 infection and vaccination information were also collected. Respondents self-reported how many COVID-19 vaccine doses they received and those who only received one dose of a two-dose series or reported never receiving a COVID-19 vaccine dose were coded as *unvaccinated or incomplete primary series*. Respondents who reported receiving a two-dose series were considered *vaccinated*. Vaccination before SARS-CoV-2 infection was based on whether the respondent reported being vaccinated 14 days or more before the self-reported COVID-19 infection date or serology test result.

2.3.1 | Serological testing and definition of SARS-CoV-2 infection

Serological testing included assays for anti-S and anti-N antibodies. Anti-S reactivity was assessed using Ortho Vitros anti-SARS-CoV-2 S1 Total Ig Assay [sensitivity, 90.0% (range, 76.9–96.0) and specificity, 100% (99.1–100)]. Anti-N reactivity was assessed using the Roche Elecsys anti-N Assay [sensitivity, 100.0% (range, 88.3–100) and specificity, 99.8% (99.7–99.9)] or Ortho Vitros anti-N Assay [sensitivity, 90.0% (range, 80.8–95.1) and specificity, 99.1% (98.4–99.5)]. The high sensitivity indicates the ability to detect infections for at least 1 year after infection.[12]

Infection status was determined using two methods – anti-N reactivity at any blood donation since June 2020 or self-report of previous SARS-CoV-2 infection. During the long-term symptoms survey respondents were asked "Since March 2020, have you been infected by SARS-CoV-2, the virus that causes COVID-19?." Respondents who reported an infection during the long-term symptoms survey, whether it was confirmed or not, along with those who were anti-N reactive, were considered previously infected. Respondents who self-reported having COVID-19 were asked the date of the infection. Individuals with anti-N nonreactivity who self-reported never testing positive for COVID-19 or being unsure of their infection status comprised the never infected group.

2.4 | Statistical analysis

We compared the prevalence of new long-term symptoms among previously infected and never infected respondents using Pearson's chi-squared tests for pairwise comparison, overall and by industry and occupation group. We calculated the prevalence differences and ratios comparing self-reported new long-term symptoms by infection status. Among respondents who reported new long-term symptoms, we compared the prevalence of new long-term symptoms lasting 4 weeks or longer by bodily system within each occupation and industry category. Analyses were conducted using RStudio statistical software (version 2022.07.1).

2.5 | Ethical review

This survey underwent ARC Institutional Review Board (IRB) approval. It was also reviewed by CDC and conducted consistent with applicable federal law and CDC policy (45 C.F.R. part 46.102(l)(2), 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq).

3 | RESULTS

3.1 | Respondent characteristics

Of the 347,447 blood donors who received the occupations survey, the response rate was 25% ($N = 86{,}131$). The occupations survey was completed by 86,131 survey respondents and 56% of the survey respondents also completed the long-term symptoms survey ($N = 48{,}149$). Among 818,361 blood donors who received the long-term symptoms survey, 272,965 responded and completed the survey (33% response rate). After exclusions, our final analytic sample include 27,907 employed ARC blood donors (Figure 1).

Over half (58.5%) of the respondents were female, 91.2% of respondents were non-Hispanic White, and the mean age was 53.0 years (Table 1). At least one pre-existing comorbidity was reported by 43.6% of respondents. The majority of respondents received two or more COVID-19 vaccine doses (85.5%). Overall, 34.7% of respondents were previously infected with SARS-CoV-2. One or more new long-term symptoms were reported by 30.9% of respondents.

3.2 | New long-term symptoms by occupation and industry

New long-term symptoms were more prevalent among the previously infected respondents compared to the never infected respondents (44.6% compared to 23.7%, respectively, $p < 0.05$) (Table 2). The occupations and industry categories along with the number of respondents who reported working within these professions are presented in Table 2. By occupation category, report of new long-term symptoms ranged from 23.9% for architectural and engineering occupations to 42.3% for food preparation and serving. By industry category, report of new long-term symptoms ranged from 26.5% for mining and manufacturing industries to 39.4% for accommodation and food industry.

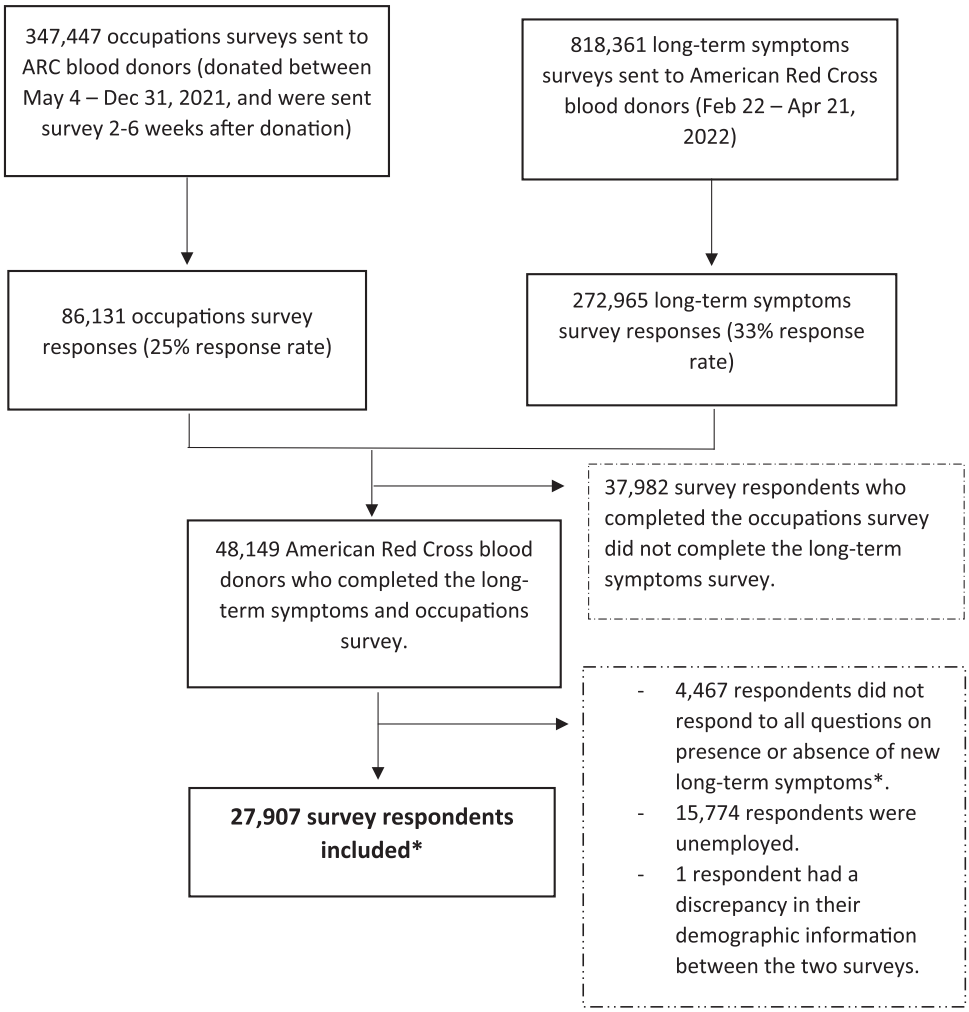

FIGURE 1 Inclusion and exclusion criteria for analysis of Long COVID and Occupations surveys. *If respondent answered survey questions for at least one group of the five bodily system symptom categories (neurological, gastrointestinal, respiratory and cardiac, mental health, and "other"), they were included.

Among previously infected respondents, the report of new long-term symptoms by occupation category ranged from 32.2% for architecture and engineering to 59.7% for food preparation and serving. By industry category, reported new long-term symptoms among those previously infected ranged from 25.9% (mining) to 54.5% (accommodation and food services). New long-term symptoms among the never infected group by occupation category ranged from 13.5% for farming, fishing, and forestry to 31.1% for healthcare support. By industry, reported new long-term symptoms among the never infected respondents ranged from 17.7% for wholesale trade to 29.2% for military. Within each occupation category besides military specific occupations, previously infected respondents were more likely to report at least one new long-term symptom compared to the never infected respondents ($p < 0.05$). Management of companies and enterprises, military, and mining industries were the only industry categories where previously infected respondents were not more likely to report new long-term symptoms compared to the never infected group ($p < 0.05$).

Among those previously infected, there were 20.9 excess cases of new long-term symptoms per 100 people compared to those never infected (95% CI: 19.8, 22.0) (Table 2). This translated to previously infected persons having 2.1 times the prevalence of new long-term symptoms compared to those never infected (95% CI: 2.1 2.2).

3.3 | Types of new long-term symptoms among previously infected respondents

Neurological symptoms – fatigue, headache, malaise, problems sleeping, problems speaking, problems with balance, tingling or numbness, difficulty thinking or concentrating, dizziness, and problems swallowing – were reported by 23.7% of the previously infected respondents (95% CI: 22.9–24.6) (Table 3). By occupation category, report of new long-term neurological symptoms ranged from 14.7% for construction and extraction to 35.2% for food preparation and

TABLE 1 Demographic and characteristics of U.S. blood donor survey respondents (*N* = 27,907).

	N (%)
Sex	
Female	16,335 (58.5)
Male	11,572 (41.5)
Age (years)	53.0 (43.0, 61.0)
Age category	
18–34	2,896 (10.4)
35–54	12,044 (43.2)
55–74	12,763 (45.7)
75 and older	204 (0.7)
Race/Hispanic ethnicity*	
White	25,389 (91.2)
Black	513 (1.8)
Hispanic	778 (2.8)
Asian	701 (2.5)
American Indian	65 (0.2)
Other	408 (1.5)
Missing	53
US Census region	
Midwest	7748 (27.8)
Northeast	6502 (23.3)
South	6701 (24.0)
West	6939 (24.9)
Missing	17
Comorbidities	
None	15,634 (56.4)
≥1 comorbidity	12,070 (43.6)
1	7019 (25.2)
2 or 3	4532 (16.2)
4 or more (4+)	519 (1.9)
Missing	203
COVID-19 vaccination status before infection	
2 or more vaccine doses	22,354 (80.2)
Unvaccinated or incomplete primary series	5523 (19.8)
Missing	30
COVID-19 vaccination status at time of new long-term symptoms survey	
2 or more vaccine doses	23,843 (85.5)
Unvaccinated or incomplete primary series	4034 (14.5)
Missing	30
SARS-CoV-2 infection status	
Previously infected	9673 (34.7)
Never infected	18,234 (65.3)
New long-term symptom since March 2020	
None	19,282 (69.1)
At least one new symptom (≥ 1)	8625 (30.9)
1 symptom	3526 (12.6)
2 or 3 symptoms	3050 (10.9)
4 or5 symptoms	1051 (3.8)
6+ symptoms	998 (3.6)

*All categories are non-Hispanic unless otherwise indicated. "other" refers to self-identification in this category.

serving. By industry category, report of new long-term neurological symptoms ranged from 15.4% for mining to 31.6% for accommodation and food industry. Other commonly reported symptoms included respiratory symptoms, which ranged from 12.4% to 33.3% by occupation and from 4.0% to 20.2% by industry, and other new long-term symptoms, which ranged from 11.5% to 37.8% by occupation and from 15.6% to 40.7% by industry category. New long-term mental health symptoms ranged from 6.9% to 19.9% by occupation and from 6.4% to 20.8% by industry. Only 4.7% of the respondents previously infected with SARS-CoV-2 reported a new long-term gastrointestinal symptom.

4 | DISCUSSION

Our study found the prevalence of new long-term symptoms lasting 4 weeks or longer varied by occupation and industry, with the highest burden observed within food preparation and food services and healthcare practitioners and technical occupations. A study from the United Kingdom similarly observed a high prevalence of new long-term symptoms among those in occupations within healthcare and food services.[8] The differences in new long-term symptoms by occupation and industry are largely reflective of SARS-CoV-2 exposure. The particularly high prevalence of these symptoms among respondents in the accommodation and food services industry, as well as the healthcare support and healthcare practitioners and technical occupations, aligns with previous research indicating elevated risk in these sectors due to higher exposure rates to SARS-CoV-2.[1,2,8,13–15]

The proportions of never infected respondents who reported new long-term symptoms were similarly high within the accommodations and food services and healthcare and social assistance industries. This suggests some occupations and industries may have characteristics in addition to exposures to SARS-CoV-2 infection which may contribute to adults reporting new long-term symptoms

TABLE 2 Prevalence (%) of new long-term symptoms (NLTS) since March 2020 within occupation and industry category by SARS-CoV-2 infection status among U.S. blood donor respondents – March 2020 to April 2022.

	SARS-CoV-2 infection status		New long-term symptoms (NLTS) since March 2020				
	Previously infected N (%)	Never infected *N* (%)	% experiencing NLTS within occupation (95% CI)	% of previously infected with NLTS (95% CI)	% of never infected with NLTS (95% CI)	Prevalence difference (95% CI)[a]	Prevalence ratio (95% CI)[b]
Overall sample (*n* = 27,907)	9,673 (34.7)[c]	18,234 (65.3)[c]	30.9 (30.4–31.5)	44.6 (43.6–45.6)	23.7 (23.1–24.3)*	20.9 (19.8–22.0)	2.1 (2.1–2.2)
Occupations							
Farming, fishing, and forestry (n = 61)	24 (39.3)	37 (60.7)	26.2 (16.2–39.3)	45.8 (26.2–66.8)	13.5 (5.1–29.6)*	32.3 (9.7–54.9)	3.4 (1.3–8.5)
Food preparation and serving (*n* = 291)	129 (44.3)	162 (55.7)	42.3 (36.6–48.2)	59.7 (50.7–68.1)	28.4 (21.7–36.1)*	31.3 (19.9–42.7)	2.1 (1.6–2.8)
Building and grounds cleaning and maintenance (*n* = 292)	105 (36.0)	187 (64.0)	29.8 (24.7–35.5)	49.5 (39.7–59.4)	18.7 (13.5–25.2)*	30.8 (19.9–41.7)	2.6 (1.9–3.8)
Transportation and material moving (*n* = 606)	228 (37.6)	378 (62.4)	29.7 (25.2–32.5)	45.2 (38.6–51.9)	18.8 (15.0–23.2)*	27.9 (20.4–35.4)	2.4 (1.9–3.1)
Installation, maintenance, and repair (*n* = 466)	185 (39.7)	281 (60.3)	25.8 (21.9–30.0)	41.1 (34.0–48.6)	15.7 (11.7–20.6)*	25.4 (17.3–33.5)	2.6 (1.9–3.6)
Community and social services (*n* = 725)	268 (37.0)	457 (63.0)	37.1 (33.6–40.7)	53.7 (47.6–59.8)	27.4 (23.4–31.7)*	26.3 (19.0–33.6)	2.0 (1.6–2.4)
Production (*n* = 716)	1327 (35.8)	2382 (64.2)	32.1 (30.6–33.6)	48.3 (45.6–51.0)	23.0 (21.3–24.8)*	25.3 (22.2–28.4)	2.1 (1.9–2.3)
Office and administrative support (*n* = 3709)	260 (36.3)	456 (63.7)	27.5 (24.3–31.0)	43.5 (37.4–49.7)	18.4 (15.0–22.4)*	25.1 (18.3–31.9)	2.4 (1.9–3.0)
Healthcare practitioners and technical (*n* = 2121)	883 (41.6)	1238 (58.4)	37.9 (35.8–40.0)	52.4 (49.1–55.8)	27.5 (25.1–30.1)*	24.9 (20.7–29.1)	1.9 (1.7–2.1)
Legal (*n* = 596)	196 (32.9)	400 (67.1)	33.7 (30.0–37.7)	47.5 (40.3–54.7)	27.0 (22.8–31.7)*	20.5 (12.4–28.6)	1.8 (1.4 –2.2)
Sales and related occupations (*n* = 2094)	780 (37.2)	1314 (62.8)	30.2 (28.3–32.3)	43.1 (39.6–46.6)	22.6 (20.4–25.0)*	20.5 (16.4–24.6)	1.9 (1.7–2.2)
Protective service (*n* = 401)	193 (48.1)	208 (51.9)	30.4 (26.0–35.2)	40.9 (34.0–48.2)	20.7 (15.5–26.9)*	20.2 (11.2–29.2)	2.0 (1.4–2.7)
Healthcare support (*n* = 372)	180 (48.4)	192 (51.6)	41.1 (36.1–46.3)	51.7 (44.1–59.1)	31.3 (24.9–38.4)*	20.94(10.4–30.4)	1.7 (1.3–2.2)
Management (*n* = 4070)	1383 (34.0)	2687 (66.0)	29.1 (27.7–30.5)	42.4 (39.8–45.1)	22.3 (20.7–23.9)*	20.1 (17.2–23.1)	1.9 (1.7–2.1)
Business and financial operations (*n* = 2566)	798 (31.1)	1768 (68.9)	29.5 (27.8–31.4)	43.1 (39.7–46.6)	23.4 (21.5–25.5)*	19.7 (15.9–23.5)	1.8 (1.6–2.1)
Education, training, and library (*n* = 2736)	967 (35.3)	1769 (64.7)	32.7 (30.9–34.5)	44.8 (41.6–48.0)	26.1 (24.0–28.2)*	18.7 (15.0–22.4)	1.7 (1.5–1.9)
Personal care and service (*n* = 581)	211 (36.3)	370 (63.7)	37.2 (33.3–41.3)	49.3 (42.4–56.2)	30.3 (25.7–35.3)*	19.0 (10.8–27.2)	1.6 (1.3–2.0)
Arts, design, entertainment, sports, and media (*n* = 713)	179 (25.1)	534 (74.9)	33.1 (29.7–36.7)	45.8 (38.4–53.4)	28.8 (25.1–32.9)*	17.0 (9/0–25.0)	1.6 (1.3–2.0)

(Continues)

TABLE 2 (Continued)

	SARS-CoV-2 infection status		New long-term symptoms (NLTS) since March 2020				
	Previously infected N (%)	Never infected *N* (%)	% experiencing NLTS within occupation (95% CI)	% of previously infected with NLTS (95% CI)	% of never infected with NLTS (95% CI)	Prevalence difference (95% CI)[a]	Prevalence ratio (95% CI)[b]
Construction and extraction (*n* = 450)	501 (25.6)	1454 (74.4)	27.1 (25.1–29.1)	37.3 (33.1–41.7)	23.5 (21.4–25.8)*	13.8 (9.3–18.3)	1.6 (1.4–1.8)
Computer and mathematics (*n* = 1955)	177 (39.3)	273 (60.7)	24.0 (20.2–28.3)	32.2 (25.5–39.7)	18.7 (14.3–23.9)*	13.5 (5.4–21.6)	1.7 (1.2–2.4)
Architecture and engineering (*n* = 1527)	479 (31.4)	1,048 (68.6)	23.9 (21.8–26.1)	32.2 (28.0–36.6)	20.1 (17.8–22.7)*	12.1 (7.5–16.7)	1.6 (1.3–1.9)
Life, physical, and social science (*n* = 761)	188 (24.7)	573 (75.3)	28.0 (24.9–31.4)	36.2 (29.4–43.5)	25.3 (21.8–29.1)*	10.9 (3.5–18.3)	1.4 (1.1–1.8)
Military specific occupations (*n* = 98)	32 (32.7)	66 (67.3)	33.7 (24.6–44.0)	40.6 (24.2–59.2)	30.3 (19.9–43.0)	10.3 (9.7–30.3)	1.3 (0.8–2.3)
Industry							
Accommodation and food services (*n* = 442)	213 (48.2)	229 (51.8)	39.4 (34.8–44.1)	54.5 (47.5–61.2)	25.3 (19.9–31.6)*	29.2 (20.1–38.3)	2.2 (1.7–2.8)
Transportation and warehousing (n = 742)	257 (34.6)	485 (65.4)	27.9 (24.7–31.3)	45.9 (39.7–52.2)	18.4 (15.1–22.1)*	27.5 (20.7–34.3)	2.5 (2.0–3.1)
Utilities (*n* = 444)	144 (32.4)	300 (67.6)	27.3 (23.2–31.7)	45.1 (36.9–53.6)	18.7 (14.5–23.6)*	26.4 (17.6–35.3)	2.4 (1.8–3.3)
Wholesale trade (*n* = 367)	141 (38.4)	226 (61.6)	27.5 (23.1–32.4)	43.3 (35.0 - 51.9)	17.7 (13.1–23.4)*	25.6 (16.2–35.0)	2.4 (1.7–3.4)
Finance and insurance (*n* = 1900)	617 (32.5)	1,283 (67.5)	28.4 (26.4–30.5)	43.8 (39.8–47.8)	21.0 (18.9–23.4)*	22.8 (18.5–27.1)	2.1 (1.8–2.4)
Retail trade (*n* = 1784)	618 (34.6)	1,166 (65.4)	30.8 (28.7–33.0)	45.2 (41.2–49.2)	23.2 (20.9–25.8)*	22.0 (17.5–26.5)	1.9 (1.7–2.2)
Administration, support, waste management, and remediation services (*n* = 394)	138 (35.0)	256 (65.0)	31.2 (26.7–36.1)	45.7 (37.2–54.3)	23.4 (18.5–29.2)*	22.3 (12.7–31.9)	1.8 (1.4–2.4)
Public administration (*n* = 2250)	766 (34.0)	1484 (66.0)	30.7 (28.8–32.6)	45.4 (41.9–49.0)	23.1 (20.9–25.3)*	22.3 (18.3–26.3)	2.0 (1.7–2.2)
Other services (*n* = 1321)	454 (34.4)	867 (65.6)	33.0 (30.5–35.6)	46.9 (42.3–51.6)	25.7 (22.9–28.8)*	21.2 (15.9–26.5)	1.8 (1.6–2.1)
Healthcare and social assistance (*n* = 3847)	1540 (40.0)	2307 (60.0)	36.7 (35.1–38.2)	49.5 (47.0–52.0)	28.1 (26.3–30.0)*	21.4 (18.3–24.5)	1.8 (1.6–1.9)
Agriculture, forestry, fishing and hunting (*n* = 326)	131 (40.2)	195 (59.8)	30.4 (25.5–35.7)	43.5 (35.0–52.4)	21.5 (16.1–28.1)*	22.0 (11.8–32.2)	2.0 (1.5–2.8)
Management of companies and enterprises (*n* = 78)	27 (34.6)	51 (65.4)	35.9 (25.6–47.6)	51.9 (32.4–70.8)	27.5 (16.3–42.0)	24.4 (2.0–46.8)	1.9 (1.0–3.3)
Manufacturing (*n* = 3084)	1023 (33.2)	2061 (66.8)	26.5 (24.9–28.1)	40.2 (37.2–43.3)	19.7 (18.0–21.4)*	20.5 (17.2–23.8)	2.0 (1.8–2.3)
Education services (*n* = 4067)	1424 (35.0)	2643 (65.0)	32.6 (31.1–34.0)	46.0 (43.4–48.6)	25.4 (23.7–27.1)*	20.6 (17.6–23.6)	1.8 (1.7–2.0)
Real estate, rental, and leasing (*n* = 546)	210 (38.5)	336 (61.5)	28.6 (24.9–32.6)	40.5 (33.8–47.5)	21.1 (17.0–26.0)*	19.4 (11.6–27.2)	1.9 (1.5–2.5)

TABLE 2 (Continued)

	SARS-CoV-2 infection status		New long-term symptoms (NLTS) since March 2020				
	Previously infected N (%)	Never infected N (%)	% experiencing NLTS within occupation (95% CI)	% of previously infected with NLTS (95% CI)	% of never infected with NLTS (95% CI)	Prevalence difference (95% CI)[a]	Prevalence ratio (95% CI)[b]
Construction (n = 929)	374 (40.3)	555 (59.7)	29.0 (26.1–32.0)	40.1 (35.1–45.3)	21.4 (18.1–25.1)*	18.7 (12.8- 24.7)	1.9 (1.5–2.3)
Arts, entertainment, and recreation (n = 523)	157 (30.0)	366 (70.0)	34.8 (30.7–39.1)	52.2 (44.1–48.6)	27.3 (22.9–32.2)*	24.9 (16.0–33.8)	1.9 (1.5–2.4)
Professional, scientific, and technical services (n = 3423)	1,001 (29.2)	2,422 (70.8)	28.3 (26.8–29.9)	39.0 (35.9–42.1)	23.9 (22.2–25.7)*	15.1 (11.8–18.4)	1.6 (1.5–1.8)
Military (n = 96)	34 (32.1)	72 (67.9)	34.0 (25.2–43.9)	44.1 (27.6–61.9)	29.2 (19.3–41.2)	14.9 (4.4–34.2)	1.5 (0.9- 2.5)
Information (n = 766)	202 (26.4)	564 (73.6)	31.2 (28.0–34.6)	40.6 (33.8–47.7)	27.8 (24.2–31.8)*	12.8 (5.4–20.2)	1.5 (1.2–1.8)
Mining (n = 49)	27 (55.1)	22 (44.9)	26.5 (15.4–41.3)	25.9 (11.9–46.6)	27.3 (11.6–50.4)	1.4 (−26.3–23.5)	1.0 (0.4–2.4)

[a]Prevalence difference calculation: previously infected with new long-term symptoms minus never infected with new long-term symptoms.

[b]Prevalence ratio calculation: previously infected with new long-term symptoms divided by never infected with new long-term symptoms.

[c]Respondents who did not report their industry category were not included in the estimates (i.e., 175 previously infected respondents and 344 never infected respondents).

*p-value for Pearson's pairwise comparison of proportions who reported at least one new long-term symptom between respondents previously and never infected with SARS-CoV-2 < 0.05.

lasting 4 weeks or longer. Some of these could include COVID-19 pandemic stressors—including exposure to death, quarantine, movement restrictions, economic hardships, burnout relating to work – which negatively impacted the physical and mental health of working populations worldwide, regardless of SARS-CoV-2 infection history.[16,17] Previously infected respondents across all occupation and industry categories had a higher burden of new long-term symptoms compared to the never infected group, suggesting some of these symptoms reported by those previously infected are likely the result of Long COVID and their SARS-CoV-2 infection history. The prevalence of new long-term symptoms among the previously infected respondents differed by occupation and industry category, suggesting the burden of these symptoms may vary across the workforce. Neurological symptoms were prevalent in our sample, with more than 20% of the previously infected respondents in most of the occupation and industry categories reporting at least one new long-term neurological symptom. Symptoms of fatigue and difficulty thinking or brain fog can impact one's ability to work and may lead to lower productivity or unemployment.[18,19] New long-term respiratory symptoms are more common among populations with a higher burden for respiratory conditions.[18] In our study, the farming, fishing, and forestry occupation and the agriculture industry had the highest proportion of new long-term respiratory symptoms. Respiratory and cardiovascular illnesses have been documented at higher rates within the agriculture industry, specifically among farmworkers, which may explain the high proportion of new long-term symptoms among these workers in our study.[20,21] These new long-term symptoms may be disabling and often impact one's ability to work and carry out daily activities, presenting a large burden to the working population[6,7,18,22,23]

Strategies to reduce the impact of new long-term symptoms could include mitigation strategies, such as improving ventilation to reduce SARS-CoV-2 infections in the workplace. Additional workplace strategies to manage existing new long-term symptoms may include caring for workers' physical and mental health by increasing accommodations that improve function for those with symptoms and prevent future disabilities.[16,24–26] Access to disability insurance and enhanced sick leave policies are additional measures that support workers.[18,25,27] Employers may also consider tailoring return to work programs by occupation and industry to account for the varied experiences of working adults with new long-term symptoms.

4.1 | Limitations

The present study was cross-sectional, so we are unable to discern the onset of new long-term symptoms relative to SARS-CoV-2 infection. Therefore, we cannot assume that these reported new long-term symptoms are attributable to SARS-CoV-2 infection. Further, some respondents may have experienced changes in their employment between the two surveys, which may not have been captured. Since the timing of these new long-term symptoms relative to prior SARS-CoV-2 infection was not collected, symptoms may have occurred before SARS-CoV-2 infection. The inclusion of never infected comparison group allowed us to estimate a baseline

TABLE 3 Prevalence (%) of new long-term symptoms by affected bodily system within each occupation and industry category among U.S. blood donors previously infected with SARS-CoV-2 – March 2020 to April 2022.

	% experiencing new long-term neurological symptom(s) (95% CI)	% experiencing new long-term gastrointestinal symptom(s) (95% CI)	% experiencing new long-term respiratory and cardiac symptom(s) (95% CI)	% experiencing new long-term mental health symptom(s) (95% CI)	% experiencing new long-term other symptom(s) (95% CI)
Overall previously infected sample (*n* = 9673)[a]	23.7 (22.9–24.6)	4.7 (4.2–5.1)	16.2 (15.5–17.0)	13.5 (12.8–14.2)	23.0 (22.2–23.9)
Occupations					
Farming, fishing, and forestry (*n* = 24)	26.1 (11.1–48.7)	0 (0–19.2)	33.3 (16.4–55.3)	13.0 (3.4–34.7)	27.3 (11.6–50.4)
Food preparation and serving (*n* = 129)	35.2 (27.1–44.1)	4.9 (0.2–10.8)	16.5 (10.8–24.4)	18.1 (12.1–26.1)	37.8 (29.5–46.9)
Building and grounds cleaning and maintenance (*n* = 105)	30.3 (21.7–40.5)	9.7 (5.0–17.5)	16.2 (9.8–25.2)	11.9 (6.6–20.2)	30.1 (21.7–40.0)
Transportation and material moving (*n* = 228)	22.7 (17.5–28.9)	6.3 (3.6–10.6)	17.8 (13.1–23.5)	7.7 (4.7–12.2)	21.0 (16.0–27.0)
Installation, maintenance, and repair(*n* = 185)	21.1 (15.5–27.9)	5.6 (2.8–10.3)	16.7 (11.6–23.2)	11.0 (7.0–16.7)	19.4 (14.1–26.1)
Community and social services (*n* = 268)	29.7 (24.3–35.8)	6.1 (3.7–10.0)	20.2 (15.5–25.7)	15.3 (11.3–20.3)	30.0 (24.5–36.0)
Office and administrative support (*n* = 1327)	25.5 (23.2–28.0)	6.4 (5.2–7.9)	18.2 (16.2–20.4)	13.8 (12.0–15.8)	27.9 (25.5–30.4)
Production (*n* = 260)	23.9 (18.9–29.8)	2.4 (1.0–5.4)	19.0 (14.4–24.5)	9.4 (6.2–13.8)	21.6 (16.8–27.3)
Healthcare practitioners and technical (*n* = 883)	29.2 (26.2–32.4)	5.3 (3.9–7.0)	18.5 (16.0–21.3)	18.9 (16.4–21.7)	28.2 (25.2–31.4)
Legal (*n* = 196)	24.7 (18.9–31.6)	3.3 (1.3–7.3)	14.1 (9.6–20.0)	17.1 (12.2–23.3)	21.0 (15.7–27.6)
Sales and related occupations (*n* = 780)	23.8 (20.8–27.0)	5.0 (3.6–6.9)	15.6 (13.1–18.4)	11.7 (9.6–14.3)	24.0 (21.0–27.2)
Protective service (*n* = 193)	27.4 (21.3–34.4)	5.8 (3.1–10.3)	20.1 (14.8–26.7)	9.5 (5.9–14.9)	20.8 (15.3–27.4)
Healthcare support (*n* = 180)	32.4 (25.6–40.0)	10.6 (6.6–16.5)	23.6 (17.6–30.7)	18.3 (13.0–25.0)	30.5 (23.8–38.0)
Management (*n* = 1383)	22.1 (19.9–24.4)	3.5 (2.6–4.6)	13.4 (11.6–15.3)	13.7 (11.9–15.7)	20.6 (18.5–22.9)
Business and financial operations (*n* = 798)	20.7 (17.9–23.7)	4.0 (2.8–5.7)	12.9 (10.7–15.5)	12.8 (10.5–15.3)	21.1 (18.3–24.1)
Education, training, and library (*n* = 967)	25.1 (22.3–28.0)	4.4 (3.2–5.9)	18.1 (15.8–20.8)	15.1 (12.9–17.6)	24.0 (21.4–26.9)
Personal care and service (*n* = 211)	27.2 (21.3–33.9)	6.4 (3.6–10.9)	18.6 (13.6–24.8)	14.5 (10.1–20.2)	27.5 (21.6–34.2)

TABLE 3 (Continued)

	% experiencing new long-term neurological symptom(s) (95% CI)	% experiencing new long-term gastrointestinal symptom(s) (95% CI)	% experiencing new long-term respiratory and cardiac symptom(s) (95% CI)	% experiencing new long-term mental health symptom(s) (95% CI)	% experiencing new long-term other symptom(s) (95% CI)
Arts, design, entertainment, sports, and media (*n* = 179)	22.5 (16.7–29.6)	6.4 (3.4–11.4)	10.9 (6.8–16.7)	19.9 (14.4 -26.7)	21.1 (15.5–28.1)
Computer and mathematics (*n* = 501)	16.6 (13.5–20.2)	2.6 (1.5–4.6)	12.4 (9.7–15.7)	10.1 (7.7 -13.2)	16.1 (13.0–19.7)
Construction and extraction (*n* = 177)	14.7 (9.9–21.1)	1.7 (0.4–5.4)	14.8 (10.0–21.3)	6.9 (3.8–12.1)	17.4 (12.3–24.1)
Architecture and engineering (*n* = 479)	15.6 (12.5–19.2)	1.7 (0.8–3.5)	15.6 (12.5–19.2)	8.4 (6.1–11.3)	11.5 (8.8–14.8)
Life, physical, and social science (*n* = 188)	19.1 (13.8–25.7)	4.4 (2.0–8.7)	14.1 (9.5–20.1)	13.4 (9.0–19.4)	13.6 (9.1–19.6)
Military specific occupations (*n* = 32)	25.8 (12.5–44.9)	3.1 (0.2–18.0)	12.5 (4.1–29.9)	12.9 (4.2–30.8)	18.8 (7.9–37.0)
Industry					
Accommodation and food services (*n* = 211)	31.6 (25.4–38.4)	7.9 (4.7–12.7)	17.0 (12.3–23.0)	20.8 (15.6–27.1)	26.6 (20.8–33.2)
Transportation and warehousing (*n* = 257)	24.9 (19.8–30.8)	3.6 (1.8–6.9)	16.3 (12.1–21.5)	12.7 (9.0–17.6)	23.2 (18.3–29.9)
Utilities (*n* = 144)	22.3 (15.9–30.3)	7.1 (3.7–13.1)	15.0 (9.7–22.2)	11.4 (6.8–18.1)	25.2 (18.5–33.2)
Wholesale trade (*n* = 141)	23.2 (16.6–31.3)	2.9 (0.9–7.8)	14.5 (9.3–21.7)	6.4 (3.2–12.2)	21.7 (15.4–29.7)
Finance and insurance (*n* = 617)	19.4 (16.4–22.8)	4.1 (2.7–6.1)	16.2 (13.4–19.4)	12.1 (9.7–15.1)	22.3 (19.1–25.8)
Retail trade (*n* = 618)	24.5 (21.1–28.2)	6.5 (4.7–8.9)	15.1 (12.3–18.2)	15.5 (12.8–18.7)	24.2 (20.9–27.9)
Administration, support, waste management, and remediation services (*n* = 138)	29.1 (21.6–38.0)	5.2 (2.3–10.7)	12.2 (7.4–19.4)	11.9 (7.1–18.8)	22.1 (15.6–30.4)
Public administration (*n* = 766)	25.6 (22.5–28.9)	5.7 (4.2–7.7)	17.8 (15.2–20.8)	12.4 (10.2–15.1)	24.8 (21.8–28.0)
Other services (*n* = 454)	23.3 (19.5–27.5)	3.6 (2.2–5.9)	14.7 (11.5–18.4)	13.7 (10.7–17.4)	25.7 (21.7–30.1)
Healthcare and social assistance (*n* = 1540)	28.3 (26.0–30.7)	6.1 (5.0–7.5)	19.1 (17.2- 21.2)	17.9 (16.0–19.9)	18.1 (13.1 – 24.3)
Agriculture, forestry, fishing and hunting (*n* = 131)	23.4 (16.6–31.9)	4.0 (1.5–9.6)	20.2 (13.7–28.5)	11,3 (6.5–18.5)	24.2 (17.2–32.9)
Management of companies and enterprises (*n* = 27)	18.5 (7.0–38.7)	3.7 (0.2–20.9)	14.8 (4.9–34.6)	11.1 (2.9–30.3)	40.7 (23.0–61.0)
Manufacturing (*n* = 1023)	20.8 (18.4–23.5)	2.7 (1.8–4.0)	15.4 (13.3–17.9)	9.4 (7.7–11.5)	19.3 (17.0–22.0)

(Continues)

TABLE 3 (Continued)

	% experiencing new long-term neurological symptom(s) (95% CI)	% experiencing new long-term gastrointestinal symptom(s) (95% CI)	% experiencing new long-term respiratory and cardiac symptom(s) (95% CI)	% experiencing new long-term mental health symptom(s) (95% CI)	% experiencing new long-term other symptom(s) (95% CI)
Education services (*n* = 1424)	25.8 (23.5–28.2)	4.3 (3.3–5.6)	17.3 (15.3–19.4)	14.2 (12.4–16.2)	24.2 (22.0–26.5)
Real estate, rental, and leasing (*n* = 210)	21.1 (15.8–27.6)	3.9 (1.8–7.7)	18.1 (13.2–24.2)	7.3 (4.3–11.9)	25.4 (19.7–32.0)
Construction (*n* = 374)	19.0 (15.1–23.4)	2.3 (1.8–5.8)	15.1 (11.6–19.3)	10.7 (7.8–14.4)	19.6 (15.7–24.2)
Arts, entertainment, and recreation (*n* = 157)	29.3 (22.3–37.4)	8.9 (5.0–15.0)	17.2 (11.7–24.6)	17.8 (12.4–24.9)	25.0 (18.5–32.8)
Professional, scientific, and technical services (*n* = 1001)	18.9 (16.5–21.5)	3.4 (2.4–4.7)	13.9 (11.8–16.3)	13.3 (11.2–15.6)	15.6 (13.5–18.1)
Military (*n* = 34)	27.3 (13.9–45.8)	0 (0–12.6)	17.7 (7.4–35.2)	9.1 (2.4–25.5)	20.6 (9.3–38.4)
Information (*n* = 202)	20.6 (15.3–27.0)	6.1 (3.3–10.6)	11.5 (7.6–16.9)	13.1 (8.9–18.7)	18.1 (13.1 – 24.3)
Mining (*n* = 27)	15.4 (5.0–35.7)	0 (0–16.6)	4.0 (0.2–22.3)	7.4 (1.3 – 25.8)	16.0 (5.3 – 36.9)

[a]Respondents who did not report their industry category were not included in the estimates (i.e., 175 previously infected respondents).

prevalence of those symptoms from other ailments. In addition, some individuals who were infected may not develop anti-N antibodies, resulting in an underestimate of previously infected respondents in our study, leading to a possible overestimate of new long-term symptoms among the never infected group.[2] Further, respondents may have been infected with SARS-CoV-2 between a negative antibody test and the survey, resulting in them being misclassified as never infected. It is also important to note that the limited sample size of some occupation and industry categories may have resulted in imprecise effect estimates. Lastly, the ARC donor population is not representative of the US population. Adults living with severe long-term symptoms or poor overall health are less likely to donate blood than healthy adults.[28] Therefore, our results may not be representative and potentially underestimate the burden of new long-term symptoms among the U.S. working population.

Long COVID was defined as symptoms lasting four or more weeks when the survey was fielded in April 2022. In July 2024, the National Academies of Sciences, Engineering, and Medicine (NASEM) refined that definition to focus on long-term symptoms lasting three or more months after an infection.[29] Our results may capture a larger group of people experiencing long-term symptoms than the recent NASEM definition and may limit comparison to more recent studies in this area. However, symptoms lasting four or more weeks are likely to impact a person's ability to work and are important to measure.

5 | CONCLUSION

Many adults developed new long-term symptoms that lasted 4 weeks or longer since the start of the COVID-19 pandemic; those with evidence of a prior SARS-CoV-2 infection experienced a higher burden of new long-term symptoms. Many public-facing jobs, including food preparation and serving, healthcare, and social services occupations and industries, had increased prevalence of SARS-CoV-2 infection and similarly an increased prevalence of at least one new long-term symptom. Working age adults who were infected with SARS-CoV-2, regardless of occupation or industry, had higher prevalence of new long-term symptoms compared to never infected respondents. We also observed differences in the types of new long-term symptoms among the previously infected group by occupation and industry category. These symptoms may impact day-to-day activities, including ability to work. Workplace prevention strategies may reduce the burden of new long-term symptoms as well as chronic symptoms due to other causes; workplace accommodations and wellness programs may provide valuable tools to workers experiencing new long-term symptoms and aid employers in maintaining a healthy workforce.[30]

AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualization of this study. Deja L. Edwards analyzed the data, designed, and drafted the tables. All authors interpreted the results and Deja L. Edwards prepared the

initial manuscript draft. Melisa M. Shah, Dallas S. Shi, Nicole D. Ford, Jessica L. Rinsky, Jefferson M. Jones, Bryan Spencer, James Haynes, and Sharon H. Saydah provided necessary revisions before submission for publication. All authors contributed to, reviewed, and approved the final draft of this paper.

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

ETHICS STATEMENT

The surveys were reviewed and approved by the Centers for Disease Control and Prevention and the Institutional Review Board at the American Red Cross.

DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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