Long COVID Cases in Wisconsin Workers Compensation Data, March 1, 2020–July 31, 2022

Acknowledgment

This report is the product of collaboration between the Occupational Health and Safety Surveillance Program within Bureau of Environmental and Occupational Health (BEOH) at the Wisconsin Department of Health Services (DHS) and Wisconsin Department of Workforce Development (DWD).

Occupational Health and Safety Surveillance Program contributors:

Komi K.S. Modji	:	Epidemiologist
Collin R. Morris	:	Epidemiologist
Paul D. Creswell	:	Senior epidemiologist
Katherine E. McCoy	:	Unit supervisor
Wendy Fall	:	Health educator
Jonathan G. Meiman	:	Former chief medical officer and state epidemiologist for Bureau of Environmental and Occupational Health
Carrie Tomasallo	:	Section chief, Environmental Epidemiology and Surveillance Section

Department of Workforce Development contributors:

Tracy Aiello	:	Management director, Workers Compensation Bureau of Claims
Steven Peters	:	Division Administrator, Workers Compensation
Stephanie Schauer	:	Manager, Communicable Diseases Immunization Section

Table of Contents

Executive summary

SARS-CoV-2 infection can result in persistent and debilitating symptoms, known as long COVID, after the acute phase of illness. How prevalent, severe and long-lasting long COVID symptoms are, remain questions of profound importance for the current and future workforce. To help address these questions, in 2021 the national Center for Workers' Compensation Studies (part of the National Institute of Occupational Safety and Health) contracted with Wisconsin and other states to analyze workers' compensation (WC) claim data to identify and characterize long COVID cases in their respective WC data. This analysis, conducted by the Department of Health Services (DHS), was made possible through a partnership with the Department of Workforce Development (DWD).

Aligned with the Centers of Disease Control and Prevention's definition, a long COVID case was defined as any worker whose lost work time was at least four weeks. An acute COVID case was defined as any worker whose lost work time was less than four weeks.

This report analyzes paid claims from March 1, 2020 – July 31, 2022, for lost work time only, as medical treatment information was not available for analysis.
This report addresses the following questions:

- How many COVID-19 claims meet this definition of long COVID cases?
- How much lost work time was attributed to long COVID claims, and how much did it cost?
- What demographic and medical risk factors are associated with long COVID claims?
- Which industries and occupations are most represented in the long COVID claims?
- What impact did vaccination have on the likelihood and length of long COVID?

To answer these questions, WC data was supplemented with information from the Wisconsin Electronic Disease Surveillance System and the Wisconsin Immunization Registry.

This report finds that:

- Out of 2,001 workers who were compensated for lost work time related to COVID-19, 11.7% (n=234) were considered long COVID based on the length of claim or disability period.
- Nearly one third (29.2%) of workers with long COVID lost work time for at least two months due to disabilities related to COVID-19. This included both total and partial disability payments.
- The demographics of long COVID cases were different from those of acute COVID cases. Long COVID cases whose median age was 48 years were significantly older than acute COVID cases whose median age was 39 years. The proportion of minorities was significantly higher among long COVID cases (23.1%) compared to acute cases (10.1%).
- The disease was more severe among long COVID cases as they were more likely to be hospitalized and were hospitalized for longer (median of 3 days) than acute COVID cases

(median of 1 day). Workers with diabetes and hypertension were significantly more likely to develop long COVID compared to other workers.

- Industry sectors with the greatest number of long COVID cases were Hospitals (n=109), Ambulatory Health Care Services (n=47), and Nursing and Residential Care Facilities (n=21). Occupations with the highest number long COVID cases were Health Diagnosing and Treating Practitioners (n=84), Nursing, Psychiatric and Home Health Aides (n=36), and Health Technologists and Technicians (n=27). This largely reflected the composition of COVID claims generally, as few other sectors filed appreciable numbers of COVID claims.
- Being vaccinated was associated with less lost work time. Workers who completed their primary COVID-19 vaccination series prior to their COVID infection were significantly less likely to develop long COVID than unvaccinated cases and cases with an incomplete primary series.

This analysis sheds light on key risk and protective factors for long COVID in Wisconsin's workforce. It does not provide an estimate of the total number of Wisconsin workers affected by long COVID, since the number of paid COVID-19 workers' compensation claims represents only a small number of COVID-affected Wisconsin workers. Nonetheless, this analysis does indicate that long COVID can result in long periods of lost work time for some Wisconsin workers. Employers and policymakers can reduce the chances of extended lost work time through support for vaccination, sick leave and workplace COVID protection measures.

1. Introduction

Persons infected by SARS-CoV-2 are at risk of prolonged symptoms or occurrence of new symptoms after the acute phase that can affect their quality of life.[1] Symptoms may include, but are not limited to, unusual or disabling fatigue, dyspnea, cough, headache, and impaired cognitive function.[1–4] These symptoms have been colloquially termed "long COVID" which has been used interchangeably with "post-COVID conditions," "long haul COVID," and several other terms.

Long COVID appears to affect a high proportion of COVID-infected persons, but prevalence estimates vary significantly across studies. In a meta-analysis and systematic review, the prevalence of long COVID among cases with evidence of prior infection (PCR, antibody test, or clinical diagnosis) was estimated at 43%, 54% among hospitalized cases, and 34% among non-hospitalized cases.[5] A large retrospective cohort of 273,618 COVID-19 survivors in the U.S. had estimated the prevalence at 57% within six months and 37% between three and six months.[6] In the U.S., the prevalence of long COVID was 7.5% with significant differences between states and demographics as of June 2022.[7]

The high prevalence estimates for long COVID have implications for the workforce. It is estimated that 1.8 million to 4.1 million full time equivalent American workers are likely to be off work due to long COVID, which is likely to worsen the current worker shortage.[8] Even among those who do return to work, persistent symptoms can impair a person's ability to perform normal job duties at full capacity. Evidence suggests that up 55% of long COVID cases experience extreme fatigue and 26% experience depression, both of which can impact one's ability to work.[9–11] In the U.S., according to the Americans with Disabilities Act (ADA), long COVID could be considered a disability if it substantially limits one or more major activities.[12]

Worker's compensation (WC) data offers a way to measure the disability period of workers with COVID-19. Paid claims for lost work time provide a formalized measure of disability through both medical absences (total disability) and diminished on-the-job capacity (partial disability). While infectious diseases are generally considered "ordinary disease[s] of life"[13] and, as such, not typically compensable under the WC system, COVID-19 has been recognized as a work-related illness.[14,15] Epidemiological analyses have shown that certain occupations are at increased risk for infection,[16–18] and states have passed presumption laws that entitle certain workers to WC benefits.[19] Workers who receive benefits for an initial COVID claim are eligible to continue to file for lost work time due to persistent COVID-19 symptoms until further medical evaluation for maximum health improvement. These data provide a window into long COVID's impact on the workforce.

This report describes the distribution of long COVID among Wisconsin workers by demographics, comorbidities, medical outcomes (hospitalization and deaths), and industry and occupation by using acute COVID-19 cases as reference group for comparison. The analysis also assesses the impact of vaccination on the duration of WC disability.

2. Background

2.1 Definitions of long COVID

Current research defines long COVID based on symptomology and time post-infection. Several large studies, including the Post-Acute Sequelae of SARS-CoV-2 (PASC) initiative, the Researching COVID to Enhance Recovery (RECOVER) study, and the Innovative Support For Patients with SARS-CoV-2 Infections (INSPIRE) study, have aimed to establish definitions and identify prevention and treatment strategies.[20–23]

According to the U.S. Centers for Disease Control and Prevention (CDC) definition, long COVID is defined as a "wide range of new, returning, or ongoing health problems people can experience four or more weeks after first being infected with the virus that causes COVID-19."[24]

The U.K.'s National Institute for Health and Care Excellence (NICE) defines long COVID as "signs and symptoms that develop during or after an infection consistent with COVID-19, continue for more than 12 weeks, and are not explained by an alternative diagnosis." [23]

According to the World Health Organization (WHO), long COVID must be a diagnosis of exclusion with a cut-off of three months. It occurs in "individuals with a history of probable or confirmed SARS-CoV-2 infection, usually 3 months from the onset of COVID-19 with symptoms that last for at least 2 months and cannot be explained by an alternative diagnosis." Symptoms may be new onset, following initial recovery from an acute COVID episode, or persist from the initial illness. Symptoms may also fluctuate or relapse over time.[23]

2.2 Risk factors

Persons who have been infected with SARS-CoV-2 are at risk of long COVID regardless of the disease manifestation and severity (for example, asymptomatic, pauci-symptomatic, or severe manifestation) during the acute phase of illness. Several analyses have identified age, sex, race and socio-economic factors, disease severity, and type of manifestations as risk factors for developing long COVID.[11] The risk of long COVID increases with age, and females are 52% more likely to develop long COVID.[11,25,26]

Evidence suggests that pre-existing medical conditions may increase the risk of long COVID, particularly diabetes, hypertension, asthma, chronic kidney disease, cardiac disease and autoimmune disorders, [1,3,11] and cases with at least three comorbidities are 110% more likely to develop long COVID.[27] Hospitalized cases are more likely to develop long COVID. [28–32] Such findings are complicated by the fact that symptoms of long COVID could be confounded with post-intensive care syndrome, which is not specific to COVID-19 and is observed following other severe illnesses.[33]

2.3 Vaccination and long COVID

Several studies demonstrated the protective effects of COVID-19 vaccination on disease severity, hospitalization, and likelihood of developing long COVID.[11,34–37] In a cohort of 33,940 patients in the U.S. Department of Veterans Affairs national health care database, there was a lower risk of developing long COVID among vaccinated compared to unvaccinated persons (hazard ratio=0.85, 95%CI: 0.82 – 0.89).[38] A community-based case control study of 1.2 million residents in the United Kingdom demonstrated a protective effect of vaccination on hospitalization and symptom duration or disease length.[36] COVID-19 vaccination was associated with a statistically significant decrease (12.8%) in odds of long COVID for the first dose of the COVID-19 vaccine and an initial 8.8% decrease followed by 0.8% decrease per week in the odds of developing long COVID after the second dose.[35]

3. Methods

3.1 Study design

This was a descriptive analysis of long COVID cases in the Wisconsin WC system during March 1, 2020–December 31, 2021, that examined demographics, medical outcomes, industry, and occupation. We also described the distribution of cases by vaccination status and the impact of vaccination of the disease length or disability period.

3.2 Data sources and linkages

The primary data source was Wisconsin WC data, which includes WC lost work time claims from private insurance carriers and some self-insured employers. These claims are initially evaluated by insurance carriers for validity and work-relatedness before being reported to the Department of Workforce Development (DWD) Workers Compensation Division.

WC data were supplemented with COVID-19 case data from the Wisconsin Electronic Disease Surveillance System (WEDSS) to obtain race, ethnicity, comorbidities, and death from COVID-19. The vital status of COVID-19 cases is automatically populated in WEDSS by Wisconsin Vital Records. The linkage between WEDSS COVID-19 case data and WC claims data was conducted using date of birth and full names by Jaro-Winkler string matching method[39] followed by a manual verification for accuracy.

Wisconsin's WC dataset does not include medical claim information. Therefore, information on hospitalization and diagnoses were obtained from hospital discharge data. Discharge data include hospitalization records of Wisconsin residents who have been admitted in an emergency room or hospitalized in Wisconsin, Minnesota, and Iowa. We linked our merged dataset to discharge data using exact date of birth and medical record number.

COVID-19 vaccination records were extracted from the statewide Wisconsin Immunization Registry (WIR) and matched with the WC claimant data. The vaccination records included full name, date of birth, vaccine type (that is, Janssen, Moderna, or Pfizer), vaccination date(s), and vaccination order (that is, first, second, and booster dose). These records may not include the records of persons who were vaccinated in Veterans Affairs centers, in pharmacies that are part of the federal retail program, or out-of-state, unless the worker reported it to their medical provider to update their vaccination records in WIR. COVID-19 vaccination records were linked to WC claimants using the same linkage method as described above. The linkage between WC claimants and COVID-19 vaccination records was conducted using date of birth and full names by Jaro-Winkler string matching method[39] followed by a manual verification for accuracy.

3.3 Case identification

We identified COVID-19 WC claims by searching for the detailed claim information (DCI) nature of injury code 83 ("COVID-19") or cause of injury code 83 ("pandemic"). To identify additional COVID-19 claims, we searched free text within the injury description field for the terms, "*corona," "covid,"* and *"ncov."* Claims identified using the text search were manually checked for accuracy and included as COVID-19 claims if the description was consistent with a COVID-related absence and the injury description was consistent with exposure and infection to COVID-19. COVID-19 vaccine-related claims were excluded from the data.

Claimants were identified from the claim data and furthermore characterized as long COVID or acute COVID, based on the case definition below in 2.5.1 (Long COVID case definition).

3.4 Industry and occupation

Wisconsin WC data did not contain standardized industry and occupation codes. Employers' North American Industry Classification System (NAICS) codes[40] were obtained by matching the WC data to Unemployment Insurance (UI) data using the federal employer identification number (FEIN). Remaining unmatched records on FEIN were matched by employer name in the UI data to obtain the NAICS code.

Occupation was coded using the free-text occupation description from the WC data and was supplemented by free-text occupation of cases reported in WEDSS. WEDSS free-text occupation was used when WC occupation was too vague (for example, "health care worker") or missing. NAICS industry codes and free-text occupation were used to derive 2010 Standardized Occupation Codes (SOC)[41] and the system matching probability using the National Institute for Occupational Safety and Health (NIOSH) Industry and Occupation Computerized Coding System (NIOCCS) autocoder.[42]

3.5 Operational definitions

3.5.1 Long COVID case definition

We adopted CDC's cut-off of four weeks in this analysis to distinguish long COVID from acute COVID.[24] We defined a long COVID case as any claimant whose claim period was at least four weeks. We defined an acute COVID case as any claimant whose claim period was less than four weeks.

To operationalize this definition, we considered the claim period (disability length), as a proxy to disease length and is defined as the period from the injury date to the full return-to-work date. The worker's full return-to-work date is the end of the WC lost work time payments. All denied claims were excluded from this case definition because they did not have any payment information including the full return-to-work date or end of WC payment date.

3.5.2 Lost work time and lost work time payments

Lost work time includes claims for both total and partial disability. In the WC system, this encompasses temporary total disability (TTD), salary,[1] and temporary partial disability (TPD).

[1] Salary is a specific type of temporary total disability payment

There were no permanent disability COVID-19 claims, although such claims would also qualify for inclusion in our dataset.

WC lost work time is the time between the injury date and the full return-to-work date. Lost work time payments are provided throughout the length of a substantiated claim.

3.5.3 Hospitalized COVID-19 cases

Cases hospitalized for COVID-19 were extracted from the hospital discharge data and must meet the following criteria:

- The hospitalization period must fall within the claim period
- Primary or secondary diagnoses must be a COVID-19 related ICD code (Appendix A)
- Admission date must be no later than 90 days from the injury date

3.5.4 COVID-19 vaccination terms

Vaccination status was assessed based on COVID-19 vaccination records in the WIR relative to the claim period. In this analysis, we defined three categories of vaccination status: (1) unvaccinated; (2) completion of primary series prior to claim period; and (3) incomplete primary series prior to their claim period.

A complete primary series was defined as having two doses of a messenger ribonucleic acid (mRNA) vaccine (Moderna or Pfizer) or one dose of viral vector (Johnson & Johnson) vaccine. We did not distinguish between those who had completed the primary series with or without boosters. A primary series was defined as partial if the claimant had exactly one dose of mRNA vaccine, with no Johnson & Johnson doses.

We defined the vaccine effectiveness date as two weeks (14 days) after administration of the second dose of mRNA or single dose of Johnson & Johnson vaccines.

An unvaccinated case was any COVID-19 positive case for whom WIR had no record of vaccination, a partial primary series effective date was recorded after their return-to-work date, or a first dose of vaccine (mRNA or Johnson & Johnson) was administered after their return-to-work date.

Cases who completed their primary series prior to their claim period are defined as cases whose injury date was at least two weeks after the second dose of mRNA vaccine or first dose of Johnson & Johnson vaccine.

Incomplete primary series cases were defined as partial primary series (exactly one dose of mRNA vaccine) prior to the injury date.

Cases whose vaccination (complete series, incomplete partial series) became effective during the claim period were excluded from the vaccination analysis (see: Impact of vaccination on claim duration).

3.6 Statistical analysis

Continuous variables (age, lost work time payment) were presented as medians and ranges; categorical variables were summarized as counts and percentages. A Pearson Chi-square test was used to test the strength of association with a significance threshold (p-value) of 0.05. A secondary post-hoc test (Fisher's exact test) was performed to determine the direction of the association when the initial Chi-square test was significant. For variables that were not normally distributed, we used Wilcoxon, Kruskal-Wallis, and the pairwise Wilcoxon tests to assess the difference between groups and determine the strength of the association between the disease length and covariates whenever relevant. We compared the mean claim period between vaccination statuses via ANOVA test and pairwise comparison adjusted by Tukey's method. Statistical tests were two-sided and performed at an alpha level of 0.05. Data were cleaned, processed, visualized, and analyzed in R V4.0.5 (R Foundation for Statistical Computing, Vienna, Austria).

4. Results

4.1 Overview

During the study period, 2,001 workers (35.6% of all COVID-19 claimants) were eligible for inclusion in the analysis, of whom 234 (11.7%) were classified as long COVID cases and 1,767 (88.3%) as acute COVID cases (Figure 1).

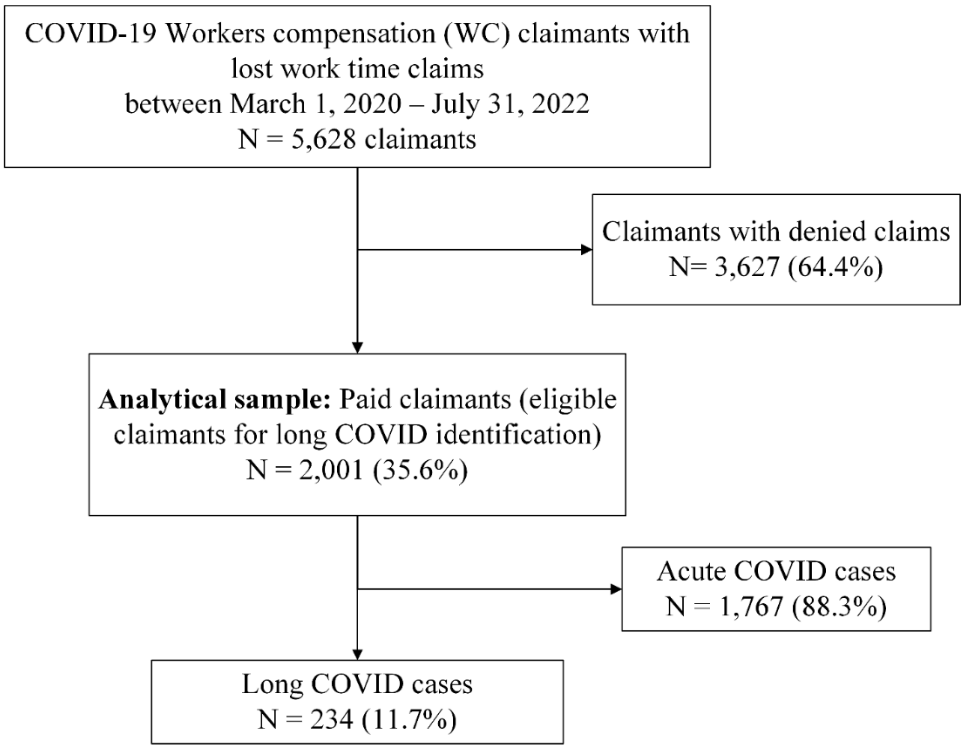

Figure 1. Long COVID identification flow chart

A total of 1,887 cases (94.3%) were linked to WEDSS to obtain additional demographics and risk factor information.

4.2 Claim payment and lost work time payment

Most long COVID cases (70.8%, n = 182) were able to return to work within 59 days after the injury date. Few cases (7.4%, n=19) experienced long COVID for at least six months (Figure 2). The median lost work time payment was $3,309, ranging from $499 to $49,406.

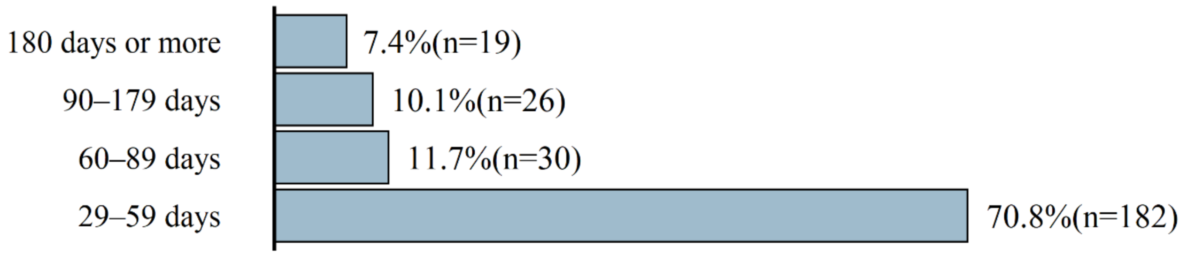

Figure 2. Distribution of long COVID cases by claim period

4.3 Factors associated with long COVID

4.3.1 Demographics

Long COVID cases differed from acute COVID cases by age and race (*Table I*). No statistically significant difference was found by sex or ethnicity. Long COVID cases were older than acute COVID cases (median of 48 vs. 39, respectively; Wilcoxon test, $p<0.001$) and racially more diverse (non-White: 23.1% vs. 10.1%, respectively; Chi-square, $p<0.02$).

Table I. Demographics of cases by disease length or type

	Acute COVID (N=1,767)	**Long COVID (N=234)**	**p-value**	**Fisher's exact test p-value**
Age				
Median [Min, Max]	39.0 [16.0, 83.0]	48.0 [20.0, 75.0]	*<0.001* (A)*	*NA*
Age category				
40 years or younger	956 (54.1%)	77 (32.9%)	*<0.001**	*<0.001**
Older than 40 years	810 (45.8%)	157 (67.1%)		*<0.001**
Sex				
Female	1322 (74.8%)	173 (73.9%)	*0.895*	*NA*
Male	342 (19.4%)	43 (18.4%)		*NA*
Missing	103 (5.8%)	18 (7.7%)		*NA*
Race category				
American Indian or Alaska Native	12 (0.7%)	4 (1.7%)	*0.011**	*0.03**
Asian	40 (2.3%)	10 (4.3%)		*0.49*
Black or African American	94 (6.4%)	39 (16.7%)		*<0.001**
Native Hawaiian or Other Pacific Islander	6 (0.3%)	1 (0.4%)		*1*
White	1,285 (72.7%)	153 (65.4%)		*<0.001**

	Acute COVID (N=1,767)	Long COVID (N=234)	p-value	Fisher's exact test p-value
Multiple race categories	7 (0.4%)	0 (0%)		*1*
Missing	228 (12.9%)	27 (11.5%)		*1*
Ethnicity				
Not Hispanic or not Latino	1,463 (82.8%)	194 (82.9%)	*0.46*	*NA*
Hispanic or Latino	102 (5.8%)	10 (4.3%)		*NA*
Missing	202 (11.4%)	30 (12.8%)		*NA*

Abbreviations: Min: Minimum, Max: Maximum. NA: not applicable
*Denotes a statistically significant difference (alpha=*0.05*)
(A): Wilcoxon test

4.3.2 Medical risk factors and outcomes

Data on comorbidities was available for 1,001 cases (50% of all cases), including 865 acute COVID cases (49.0% of all acute COVID cases) and 145 long COVID cases (61.2% of all long COVID cases). Diabetes and hypertension were significantly associated with long COVID (Chi-square, $p<0.05$) (*Table* II). We identified 69 hospitalized cases of COVID-19 in the hospital discharge data. Long COVID cases were also more likely to be hospitalized than acute COVID cases (*Table* III, Chi-square, $p<0.001$). One fatality was attributed to COVID-19 among acute COVID cases.

Table II. Comorbidities by disease type

	Acute COVID (N=865)	Long COVID (N=145)	p-value	Fisher's exact test p-value
Diabetes				
No	831 (96.1%)	131 (90.3%)	*0.005**	*0.001**
Yes	34 (3.9%)	14 (9.7%)		*0.001**
Chronic kidney disease				
No	862 (99.7%)	142 (97.9%)	*0.056*	*NA*
Yes	3 (0.3%)	3 (2.1%)		*NA*
Hypertension				
No	784 (90.6%)	119 (80.2%)	*0.003**	
Yes	81 (9.4%)	26 (17.9%)		

	Acute COVID (N=865)	Long COVID (N=145)	p-value	Fisher's exact test p-value
Asthma				
No	782 (90.4%)	125 (86.2%)	*0.162*	*NA*
Yes	83 (9.6%)	20(13.8%)		*NA*
Cardiac disease				
No	850 (98.3%)	143 (98.6%)	1	*NA*
Yes	15 (1.7%)	2 (1.4%)		*NA*
Immunocompromised				
No	857 (99.1%)	142 (97.9%)	*0.426*	*NA*
Yes	8 (0.9%)	3 (2.1%)		*NA*

Abbreviations: * Denotes a statistically significant difference (alpha=*0.05*).
NA: not applicable

Table III. Distribution of COVID-19 medical outcomes by disease type

	Acute COVID (N=1,767)	Long COVID (N=234)	p-value	Fisher's exact test p-value
COVID hospitalization				
No	1,720 (97.3%)	212 (90.6%)	*<0.001**	*<0.001**
Yes	47 (2.7%)	22 (9.4%)		*<0.001**
COVID death				
No	1,766 (99.9%)	234 (100%)	*1*	*NA*
Yes	1 (0.06%)	0 (0%)		*NA*

Abbreviations: * Denotes a statistically significant difference (alpha=*0.05*).
NA: not applicable

Duration of hospitalization was longer among long COVID cases than acute COVID cases (Wilcoxon test, $p<0.001$). The median hospitalization length for long COVID cases was three days (range: 1–21 days) compared to acute COVID cases whose median hospitalization period was one day (range: 1–8 days) (Figure 3).

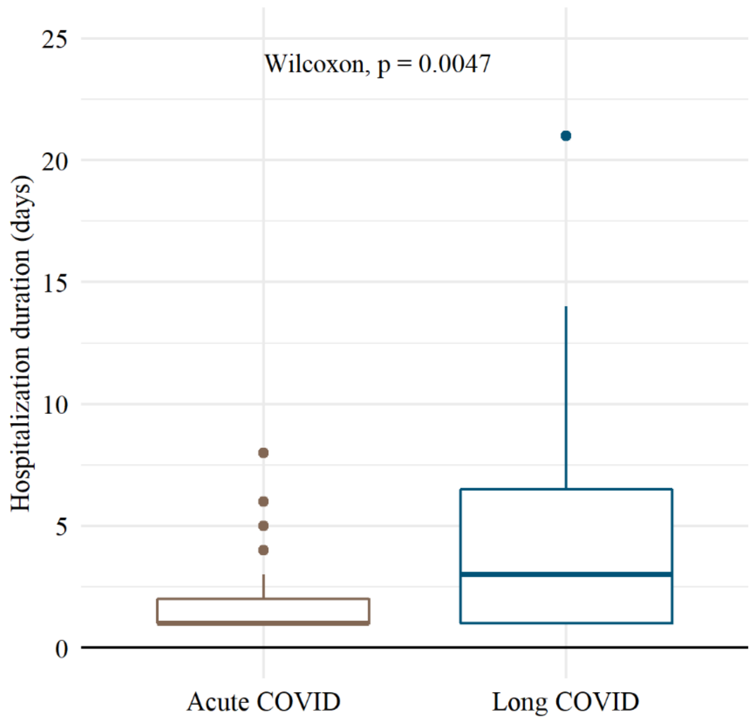

Figure 3. Hospitalization duration by disease type

Notes: Boxes and horizontal bars denote interquartile range (IQR). Points represent influential points or outliers.

4.4 Cases by industry and occupation

4.4.1 Industry

The top three industry sectors with the highest long COVID case count were Hospitals (n=109), Ambulatory Health Care Services (n=47) and Nursing and Residential Care Facilities (n=21). There was a statistically significant difference between the industry groups and the disease length (Chi-square, p<0001). The proportion of long COVID among workers in Hospitals (13.9%; 95% CI: 11.3 – 16.5) was higher than that of workers in Ambulatory Health Care Services (8.2%; 95% CI: 5.8 – 10.5) (Table IV).

Table IV. Industry sectors by disease length (acute COVID and long COVID)

Industry subsector	Acute COVID (N=1,767)	Long COVID (N=234)	95% CI of the proportion of long COVID
Administrative and Support Services	76(93.8%)	5(6.2%)	0.8 – 11.6
Ambulatory Health Care Services	529(91.8%)	47(8.2%)	5.8 – 10.5
Executive, Legislative, and Other General Government Support	96(84.2%)	18(15.8%)	8.5 – 23.0
Food Manufacturing	22(81.5%)	5(18.5%)	2.3 – 34.8
Hospitals	675(86.1%)	109(13.9%)	11.3 – 16.5
Machinery Manufacturing	35(85.4%)	6(14.6%)	2.9 – 26.3
Management of Companies and Enterprises	48(84.2%)	9(15.8%)	5.5 – 26.1
Nursing and Residential Care Facilities	210(90.9%)	21(9.1%)	5.2 – 13.0
All other subsectors combined	54(83.1%)	11(16.9%)	6.9 – 26.9

Notes: Industry sector that had less than five long COVID cases were grouped into “All other subsectors combined.”
Abbreviations. CI: Confidence interval

4.4.2 Occupation

The top three minor occupation groups with the highest long COVID case count were Health Diagnosing and Treating Practitioners (n=84), Nursing, Psychiatric and Home Health Aides (n=36), Health Technologists and Technicians (n=27). There was no statistically significant difference in the distribution of long COVID by occupation (Chi-square, *p=0.33*) (Table V).

Table V. Minor occupation groups by disease length (acute COVID and long COVID)

Minor occupation group	Acute COVID (N=1,767)	Long COVID (N=234)	95% CI of the proportion of long COVID
Health Diagnosing and Treating Practitioners	673(88.9%)	84(11.1%)	8.7 – 13.5
Health Technologists and Technicians	226(89.3%)	27(10.7%)	6.6 – 14.7
Law Enforcement Workers	35(77.8%)	10(22.2%)	8.4 – 40.0
Material Recording, Scheduling, Dispatching, and Distributing Workers	15(75.0%)	5(25.0%)	3.1 – 46.9
Nursing, Psychiatric, and Home Health Aides	230(86.5%)	36(13.5%)	9.1 – 18.0
Other Healthcare Support Occupations	49(86.0%)	8(14.0%)	4.3 – 23.8
Other Management Occupations	25(83.3%)	5(16.7%)	2.1 – 31.3
Other Personal Care and Service Workers	83(87.4%)	12(12.6%)	5.5 – 19.8
Other Production Occupations	18(78.3%)	5(21.7%)	2.7 – 40.8
All other occupation groups combined	292(90.1%)	32(9.9%)	6.5–13.3

Notes: Major occupation groups that had less than five long COVID cases were grouped into "All other occupation groups combined."

4.5 Impact of vaccination on claim duration

During our study period and according to our operational definitions, 13.3% of our cases completed their primary series prior to the onset of COVID-19 (date of injury) and there was a statistically significant association between the vaccination status and the likelihood of developing long COVID (*Table VI*, Chi-square, $p<0.001$). Cases who completed their primary series are less likely to develop long COVID in comparison to unvaccinated cases and cases with an incomplete primary series (ANOVA, $p<0.001$, Figure 4).

Table VI. Distribution of long and acute cases by primary series vaccination status

Vaccination status	Acute COVID (N=1,765)	Long COVID (N=217)	Pearson Chi-square p-value	Total (N=1,982)
Completed primary series	253 (97.3%)	7 (2.7%)	*< 0.001*	260 (13.3%)
Incomplete primary series prior to claim	45 (84.9%)	8 (15.1%)		53 (1.3%)
Unvaccinated	1,467 (87.9)	202 (12.1%)		1,669 (85.4%)

Note: We excluded from this analysis, any case whose vaccination became effective during the claim period (that is, between the injury date and the return-to-work date).

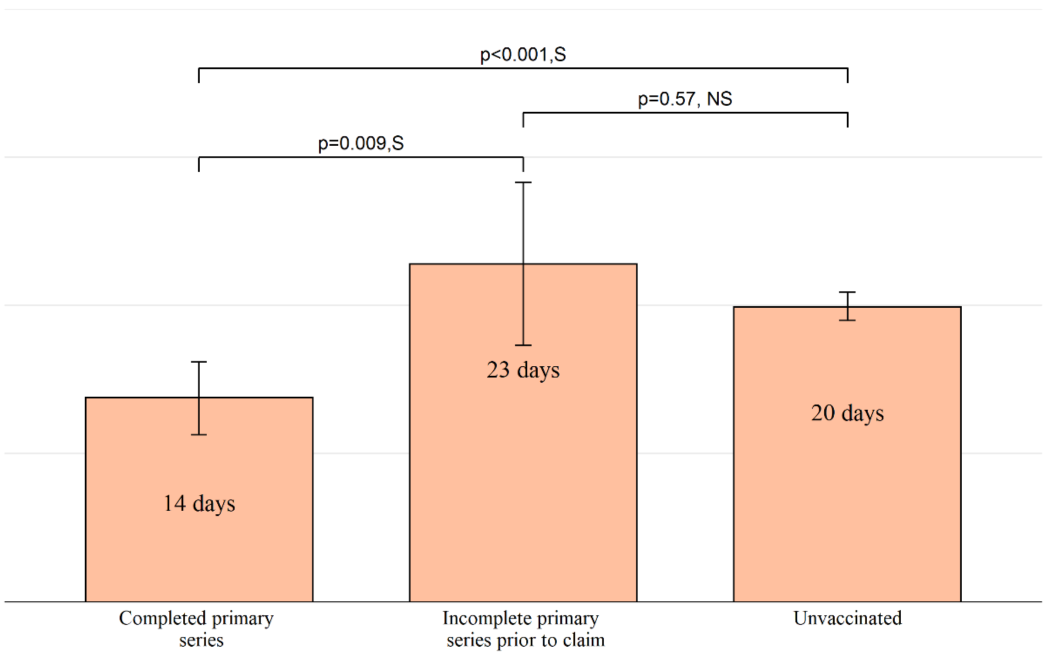

Figure 4. Comparison of mean claim period length by vaccination status

Abbreviations: S stands for statistically significant ($p<0.05$) and NS stands for not statistically significant (that is, $p>0.05$). Errors bars represent confidence interval of the mean (see table in Appendix B).

5. Conclusions

There is growing evidence that long COVID will have a considerable impact on the workforce for years to come. In this analysis, we see evidence of long COVID's disabling effects on the workforce as reflected in the WC system. This is one of the first examinations of long COVID in the WC system, although there will likely be a need for such analyses in years to come. Claims for long COVID fit many of the established and emerging patterns of long COVID distribution and risk factors from other studies, with older claimants and those with co-morbidities having a greater likelihood of long COVID claims. This analysis also adds to a growing body of literature indicating the preventive effects of vaccination on long COVID, with vaccinated claimants showing less likelihood of long COVID than unvaccinated claimants.

References

1. Tenforde MW, Kim SS, Lindsell CJ, et al. Symptom Duration and Risk Factors for Delayed Return to Usual Health Among Outpatients with COVID-19 in a Multistate Health Care Systems Network - United States, March-June 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(30):993-998. doi:10.15585/mmwr.mm6930e1

2. Carfi A, Bernabei R, Landi F. Persistent Symptoms in Patients After Acute COVID-19. *JAMA Network*. 2020;324(6):603-605. doi:doi:10.1001/jama.2020.12603

3. Crook H, Raza S, Nowell J, Young M, Edison P. Long covid—mechanisms, risk factors, and management. *BMJ*. 2021;374:n1648. doi:10.1136/bmj.n1648

4. Nersesjan V, Fonsmark L, Christensen RHB, et al. Neuropsychiatric and Cognitive Outcomes in Patients 6 Months After COVID-19 Requiring Hospitalization Compared With Matched Control Patients Hospitalized for Non-COVID-19 Illness. *JAMA Psychiatry*. 2022;79(5):486-497. doi:10.1001/jamapsychiatry.2022.0284

5. Chen C, Haupert SR, Zimmermann L, Shi X, Fritsche LG, Mukherjee B. Global Prevalence of Post-Coronavirus Disease 2019 (COVID-19) Condition or Long COVID: A Meta-Analysis and Systematic Review. *The Journal of Infectious Diseases*. 22AD;136. Accessed August 26, 2022. https://doi.org/10.1093/infdis/jiac136

6. Taquet M, Dercon Q, Luciano S, Geddes JR, Husain M, Harrison PJ. Incidence, co-occurrence, and evolution of long-COVID features: A 6-month retrospective cohort study of 273,618 survivors of COVID-19. *PLOS Medicine*. 2021;18(9):e1003773. doi:10.1371/journal.pmed.1003773

7. Centers for Disease Control and Prevention. Nearly One in Five American Adults Who Have Had COVID-19 Still Have "Long COVID." Published June 22, 2022. Accessed August 26, 2022. https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2022/20220622.htm

8. Bach K. New data shows long Covid is keeping as many as 4 million people out of work. Brookings. Published August 24, 2022. Accessed August 26, 2022. https://www.brookings.edu/research/new-data-shows-long-covid-is-keeping-as-many-as-4-million-people-out-of-work/

9. Menges D, Ballouz T, Anagnostopoulos A, et al. Burden of post-COVID-19 syndrome and implications for healthcare service planning: A population-based cohort study. *PLoS One*. 2021;16(7):e0254523. doi:10.1371/journal.pone.0254523

10. Vanichkachorn G, Newcomb R, Cowl CT, et al. Post–COVID-19 Syndrome (Long Haul Syndrome): Description of a Multidisciplinary Clinic at Mayo Clinic and Characteristics of the Initial Patient Cohort. *Mayo Clin Proc*. 2021;96(7):1782-1791. doi:10.1016/j.mayocp.2021.04.024

11. Subramanian A, Nirantharakumar K, Hughes S, et al. Symptoms and risk factors for long COVID in non-hospitalized adults. *Nat Med*. 2022;28(8):1706-1714. doi:10.1038/s41591-022-01909-w

12. Rights (OCR) O for C. Guidance on “Long COVID” as a Disability Under the ADA, Section 504, and Section 1557. HHS.gov. Published July 26, 2021. Accessed December 15, 2021. https://www.hhs.gov/civil-rights/for-providers/civil-rights-covid19/guidance-long-covid-disability/index.html

13. Britt KE. Workers’ Comp and Contagious Disease: History and Future. Published online 2021:4.

14. Wisconsin State Legislature. *Wis. Stat. § 102.03(6)*.; 2020. Accessed September 30, 2021. https://docs.legis.wisconsin.gov/statutes/statutes/102/03/6

15. Carlsten C, Gulati M, Hines S, et al. COVID-19 as an occupational disease. *Am J Ind Med*. 2021;64(4):227-237. doi:10.1002/ajim.23222

16. Pray IW, Grajewski B, Morris C, et al. Measuring work-related risk of COVID-19: comparison of COVID-19 incidence by occupation and industry – Wisconsin, September 2020-May 2021. *Clinical Infectious Diseases*. Published online August 4, 2022:ciac586. doi:10.1093/cid/ciac586

17. Bonde JPE, Sell L, Johan Høy JH, et al. Occupational risk of COVID-19 across pandemic waves: a two-year national follow-up study of hospital admissions. *Scand J Work Environ Health*. 2022;48(8):672-677. doi:10.5271/sjweh.4056

18. Waltenburg MA, Victoroff T, Rose CE, et al. Update: COVID-19 Among Workers in Meat and Poultry Processing Facilities ― United States, April–May 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:887-892. doi:http://dx.doi.org/10.15585/mmwr.mm6927e2

19. Hyman MH, Talmage JB, Hegmann KT. Evaluating Covid-19 Injury Claims With a Focus on Workers’ Compensation. *Journal of Occupational & Environmental Medicine*. 2020;62(9):692-699. doi:10.1097/JOM.0000000000001950

20. NIH launches new initiative to study “Long COVID.” National Institutes of Health (NIH). Published February 23, 2021. Accessed August 26, 2022. https://www.nih.gov/about-nih/who-we-are/nih-director/statements/nih-launches-new-initiative-study-long-covid

21. RECOVER Studies | Researching COVID to Enhance Recovery. Accessed August 26, 2022. https://studies.recovercovid.org/

22. Covid Inspire. Accessed August 26, 2022. https://www.covidinspire.org/#get-started

23. World Health Organization. A clinical case definition of post COVID-19 condition by a Delphi consensus, 6 October 2021. A clinical case definition of post COVID-19 condition by a Delphi consensus, 6 October 2021. Published October 6, 2021. Accessed February 8, 2022.

https://www.who.int/publications-detail-redirect/WHO-2019-nCoV-Post_COVID-19_condition-Clinical_case_definition-2021.1

24. CDC. Post-COVID Conditions. Centers for Disease Control and Prevention. Published February 11, 2020. Accessed September 30, 2021. https://www.cdc.gov/coronavirus/2019-ncov/long-term-effects/index.html

25. Bai F, Tomasoni D, Falcinella C, et al. Female gender is associated with long COVID syndrome: a prospective cohort study. *Clin Microbiol Infect*. Published online November 9, 2021:S1198-743X(21)00629-7. doi:10.1016/j.cmi.2021.11.002

26. Thompson EJ, Williams DM, Walker AJ, et al. Long COVID burden and risk factors in 10 UK longitudinal studies and electronic health records. *Nat Commun*. 2022;13(1):3528. doi:10.1038/s41467-022-30836-0

27. Nune A, Durkowski V, Titman A, et al. Incidence and risk factors of long COVID in the UK: a single-centre observational study. *J R Coll Physicians Edinb*. 2021;51(4):338-343. doi:10.4997/JRCPE.2021.405

28. Bregman H, Sandberg N, Little D, Barkley E. Patients with Comorbidities Seek Care for Long-COVID-Like Symptoms at Higher Rates Than Others. Epic Research. Published June 28, 2022. Accessed August 29, 2022. https://epicresearch.org/articles/patients-with-comorbidities-seek-care-for-long-covid-like-symptoms-at-higher-rates-than-others

29. Jones R, Davis A, Stanley B, et al. Risk Predictors and Symptom Features of Long COVID Within a Broad Primary Care Patient Population Including Both Tested and Untested Patients. *Pragmat Obs Res*. 2021;12:93-104. doi:10.2147/POR.S316186

30. Sudre CH, Murray B, Varsavsky T, et al. Attributes and predictors of long COVID. *Nat Med*. 2021;27(4):626-631. doi:10.1038/s41591-021-01292-y

31. Anthony L. Komaroff MD. Predictors of “Long COVID-19.” *NEJM Journal Watch*. 2021;2021. doi:10.1056/nejm-jw.NA53380

32. Iqbal FM, Lam K, Sounderajah V, Clarke JM, Ashrafian H, Darzi A. Characteristics and predictors of acute and chronic post-COVID syndrome: A systematic review and meta-analysis. *EClinicalMedicine*. 2021;36. doi:10.1016/j.eclinm.2021.100899

33. CDC. Post-COVID Conditions: Information for Healthcare Providers. Centers for Disease Control and Prevention. Published February 11, 2020. Accessed January 24, 2022. https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/post-covid-conditions.html

34. Tenforde MW, Self WH, Adams K, et al. Association Between mRNA Vaccination and COVID-19 Hospitalization and Disease Severity. *JAMA*. 2021;326(20):2043-2054. doi:10.1001/jama.2021.19499

35. Ayoubkhani D, Bermingham C, Pouwels KB, et al. Trajectory of long covid symptoms after covid-19 vaccination: community based cohort study. *BMJ*. 2022;377:e069676. doi:10.1136/bmj-2021-069676

36. Antonelli M, Penfold RS, Merino J, et al. Risk factors and disease profile of post-vaccination SARS-CoV-2 infection in UK users of the COVID Symptom Study app: a prospective, community-based, nested, case-control study. *Lancet Infect Dis*. Published online September 1, 2021. doi:10.1016/S1473-3099(21)00460-6

37. Mumtaz A, Sheikh AAE, Khan AM, et al. COVID-19 Vaccine and Long COVID: A Scoping Review. *Life (Basel)*. 2022;12(7):1066. doi:10.3390/life12071066

38. Al-Aly Z, Bowe B, Xie Y. Long COVID after breakthrough SARS-CoV-2 infection. *Nat Med*. 2022;28(7):1461-1467. doi:10.1038/s41591-022-01840-0

39. Friendly F. Jaro–Winkler Distance Improvement For Approximate String Search Using Indexing Data For Multiuser Application. *J Phys: Conf Ser*. 2019;1361:012080. doi:10.1088/1742-6596/1361/1/012080

40. U.S. Census Bureau. North American Industry Classification System (NAICS). North American Industry Classification System. Published 2022. Accessed April 18, 2022. https://www.census.gov/naics/?58967?yearbck=2012

41. U.S. Bureau of Labor Statistics. 2010 Standard Occupational Classification System. Standard Occupational Classification. Accessed April 18, 2022. https://www.bls.gov/soc/2010/2010_major_groups.htm

42. NIOCCS. CDC - NIOSH Industry and Occupation Computerized Coding System (NIOCCS) - NIOSH. Published 2021. Accessed September 30, 2021. https://csams.cdc.gov/nioccs/HelpWebService.aspx

Appendix A. List of COVID-19 ICD codes

ICD CODE	DEFINITION
J12.89	Pneumonia case confirmed as due to the 2019 novel coronavirus (COVID-19)
J20.8	Acute bronchitis confirmed as due to COVID-19
J40	Bronchitis not otherwise specified (NOS) due to the COVID-19
J22	Lower respiratory infection documented as being associated with COVID-19
J80	Acute respiratory distress syndrome (ARDS) due to COVID-19
Z03.818	Concern about possible exposure to COVID-19
Z20.828	Actual exposure to COVID-19
R05	Cough
R06.02	Shortness of breath
R50.9	Fever, unspecified
U07.1	Confirmed or presumptive case of COVID-19
J98.8	Respiratory infection not otherwise specified
Z11.59	COVID-19 screening with negative or unknown test result
O98.5	COVID-19 infection in pregnancy, childbirth, and the puerperium
Z86.16	Personal history of COVID-19
M35.81	Multisystem inflammatory syndrome (MIS)
M35.89	Other specified systemic involvement of connective tissue
J12.82	Pneumonia due to coronavirus disease 2019
U09.9	Post COVID-19 condition, unspecified

Appendix B. Claim period by vaccination status

Vaccination status	Mean ± SE (days)	95% CI of the mean
Completed primary series	13.8 ± 1.3	11.3–16.2
Incomplete primary series prior to claim	22.8 ± 2.8	17.3–28.3
Unvaccinated	19.9 ± 0.5	19.0–20.9