Surveillance of Post-COVID Conditions using the Washington State Workers' Compensation System, 2020-2022

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DEFINITIONS

CDC	Centers for Disease Control and Prevention
HELSA	Washington's Health Emergency Labor Standards Act
ICD-10-CM	International Classification of Diseases, Tenth Revision, Clinical Modification
KOS	Kept on Salary
L&I	Washington State Department of Labor and Industries
NAICS	North American Industry Classification System
OIICS	Occupational Injury and Illness Classification System
OSHA	Occupational Safety and Health Administration
PCC	Post-COVID Conditions
RTW	Return to work
SF	Washington Industrial Insurance State Fund
SHARP	Safety and Health Assessment and Research for Prevention
SI	Self-insured
WC	Workers' Compensation
WCIRB	Workers' Compensation Insurance Rating Bureau of California

KEYWORDS

Washington workers compensation; SHARP; long COVID; post-COVID conditions; PASC;

EXECUTIVE SUMMARY

We estimated the prevalence of "long COVID" or post-COVID conditions among Washington workers with claims for COVID-19 in the state workers' compensation system using two methods. We then examined the impact of post-COVID conditions on return to work. We define occupational post-COVID conditions as a diverse health problems occurring in individuals with a history of SARS-CoV-2 infection attributed to work with *at least 28 days of symptoms* after the confirmatory positive test. This study used data from Washington State Fund and self-insured worker's compensation claims established between February 2020 and March 2022. Non-hospitalized workers, rejected claims, and fatalities were included.

Key Findings:

- We find that 6-9% of workers' compensation claimants for acute COVID-19 will go on to develop post-COVID conditions (PCC), i.e. symptoms lasting for 28 days or more after the first positive test. This equates to between 717 and 1,134 claimants in our study period. Furthermore, 2-3% will have symptoms lasting for four months or more.
- At six months post-infection, half of hospitalized claimants and a quarter of non-hospitalized claimants with post-COVID conditions remain off work. After returning to work, 17% of PCC claimants required reduced hours and 12% required modified job duties.
- Among the 91% of post-COVID condition claims that were compensable, the median claim cost paid-to-date was $6,911 (25% have less than $3,085; 75% have less than $24,383). Among the 88% of PCC claims with paid time loss, the median number of paid days was 45 days (25% have less than 28 days; 75% have less than 88 days). Since 85% of claims were still open at time of reporting, these values are subject to increase.
- Thirteen claimants had permanent partial disability and seven had total permanent disability resulting from their post-COVID conditions.
- Pulmonary and cognitive post-COVID conditions tended to have the longest symptom durations, with a median duration each of over ten months. Mental health conditions such as depression and anxiety were reported by 20% of claimants with post-COVID conditions.

Comparison with external research:

Other studies on post-COVID conditions in worker compensation systems use medical billing data to estimate prevalence and cost. As a secondary analysis, we partially replicated these methods. We found a prevalence of 24 to 45% of PCCs among COVID-19 claims with one or more medical bills submitted to Labor and Industries. We believe this prevalence is an overestimate because claims with medical billing data were not representative of all COVID-19 claims. Claims with medical billing data were more likely to involve hospitalization and had a higher median claimant age. By comparison, our primary study captured a more diverse set of workers who engaged less with medical services but whose symptoms, such as fatigue and brain fog, impacted their return-to-work. Additionally, these methods exclude self-insured claims, which covers many healthcare workers. In conclusion, while medical billing data is readily available and richly detailed, it does not capture the full spectrum of post-COVID condition cases.

INTRODUCTION

As of December 2022, the CDC describes post-COVID conditions (PCC) or "long COVID" on their public website as: "… a wide range of new, returning, or ongoing health problems that people experience after being infected with the virus that causes COVID-19. Most people with COVID-19 get better within a few days to a few weeks after infection, so at least four weeks after infection is the start of when post-COVID conditions could first be identified" [1]. There is no single accepted case definition for post-COVID conditions at this time. For another example, the World Health Organization created a collaborative case definition that uses four months as the minimum duration of symptoms to qualify a continued illness as a post-COVID condition [2]. We have based our case definition on the CDC's language because this grant was funded by the CDC and we can choose to apply a stricter case definition *post-hoc*.

Typical symptoms during the acute phase of COVID-19 include fever, chills, cough, shortness of breath, fatigue, muscle aches, loss of taste and/or smell, nausea, and diarrhea. Long-term symptoms and diseases include persistent loss of taste or smell to stroke, renal failure, myocarditis, neurological syndromes, COVID-associated thrombosis, and pulmonary fibrosis [3]. Many symptoms associated with post-COVID conditions can be associated with other health conditions and with the stress of the pandemic.

The underlying causes of post-COVID conditions is still unknown. Three current theories are: viral persistence causing systemic inflammation; damage to the blood vessels of the lungs from micro-clots; and abnormal immune system activity. Additionally, there are complications from prolonged hospitalization, such as damage from intubation, bedrest, and malnutrition [4, 5]. Viral infection can disrupt the autonomic nervous system resulting in postural hypotension, tachycardia, and other orthostatic intolerance syndromes [5]. There is evidence to suggest that the Delta variant of COVID-19 is more likely to result in post-COVID conditions compared to other variants [6].

The estimated prevalence of post-COVID conditions varies from 5% to 80% among persons with a history of COVID-19. Estimates are strongly influenced by the method used to collect post-COVID symptom information and the selected comparison group [7]. At one month post-infection, CDC estimates that 13% of all COVID-19 cases have a post-COVID condition. At 3 months post-infection, CDC estimates that 2.5% of all COVID-19 cases continue to experience post-COVID conditions [1].

The Workers' Compensation Insurance Rating Bureau of California® (WCIRB) published a 2022 report estimating prevalence of "Long COVID" in the California Workers' Compensation System [8]. We will be partially replicating the WCIRB's methods (study B) as their report was one of the first large studies on post-COVID conditions in a workers' compensation system and it has been influential in the field.

In this study, we examine the impact of post-COVID conditions on an individual's ability to return to work (RTW). Using data from the Washington State Department of Labor and Industries (L&I) workers' compensation system, we estimated the prevalence of post-COVID conditions among workers who contracted COVID-19 at work. We do not anticipate that we will achieve highly accurate prevalence

statistics, given the limitations of workers' compensation system as a data source and the ill-defined nature of post-COVID conditions. We characterized the symptoms experienced by workers with post-COVID conditions that result in prolonged time off of work, reductions in a worker's hours, and/or changes to job duties.

METHODS

Our operating case definition is as follows: Occupational post COVID-19 conditions occur in individuals with a history of SARS-CoV-2 infection attributed to work with at least 28 days of symptoms after the confirmatory positive test. We used two data sources and methods for determining the duration of symptoms, which resulted in two prevalence estimates for post-COVID conditions.

Data Source

The primary data source was administrative data and digitized claim documents generated by the Washington State workers' compensation system. In Washington State, nonfederal employers are required to obtain workers' compensation insurance through L&I unless they meet specific requirements to self-insure or are covered under an alternative workers' compensation program. L&I's State Fund insurance program provides coverage for approximately 1.9 million (about two-thirds) of the workers in the state and 99.7% of all employers. Data from both the State Fund insurance program and the self-insurance program are entered into L&I's Industrial Insurance Data Warehouse (IIDW) which contains both medical diagnoses and administrative codes.

Claims for work-related COVID-19 were captured through ongoing surveillance of acute COVID-19 illnesses in Washington State workers' compensation system. The methods for this surveillance are described in greater detail elsewhere [9]. We routinely query claims from both State Fund and self-insured programs using keywords, ICD-10-CM codes, and Occupational Injury and Illness Classification System (OIICS) codes related to COVID-19. These criteria are sufficiently broad to capture claims filed for all phases of COVID-19 recovery, including the initial exposure, the acute phase of the illness, and post-COVID conditions. Work-relatedness is either presumed from worker's occupation (ex. first responders, medical staff, frontline workers with contact with the general public) or determined through attestations from any worker that they were exposed to ill coworkers or clients. Claims rejected by L&I for insufficient evidence of workplace exposure may be included. We accept positive PCR, rapid, or antigen test results as proof of COVID-19 infection. If the test date is missing, we presume it to be the claim injury date. We restricted the cohort to claims with sufficient evidence of a work-related exposure, with a positive test, and established at least 6 months before case review began (e.g. between 2/1/2020 and 3/31/2022, N = 12,376 claims). Symptom duration is not systematically recorded for all claims in our COVID-19 surveillance system.

While L&I regulates self-insured employers, L&I does not directly adjudicate these claims. We have access to limited medical billing data and fewer claim records for self-insured claims. As healthcare is a predominantly self-insured industry, this is an important limitation.

We should note that the ICD-10-CM emergency code "U09.9 Post COVID-19 condition" was explored as a case-capture criteria. However, only 33 claims had a medical bill with this diagnosis at the time of reporting, too few to make this a valuable case-capture criteria.

Additional information comes from the routine linkage of COVID-19 claims with the Washington State Department of Health's (DOH) COVID-19 contact tracing datasets, thanks to a data sharing agreement for research purposes. The DOH dataset provides information on comorbidities, race/ethnicity, and hospitalization. More recent claims may lack this data as contact tracing priorities change.

Study A: Estimating Post-COVID Condition Prevalence through Manual Claim Review

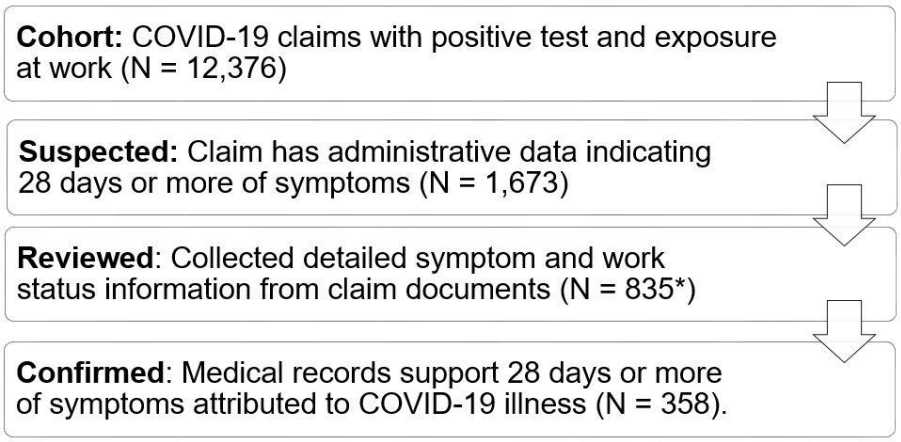
In study A, we reviewed the medical documentation for a random subset of COVID-19 claims suspected for post-COVID conditions to confirm the duration of symptoms and built a return-to-work timeline.

As manual case review is a time intensive process and staff resources are limited, first we used existing administrative data to determine which claims likely had 28 days or more of symptoms ("suspected case") then we confirmed that duration through manual case review ("confirmed case"). We approximated symptom duration using: (A) the duration of medical treatment, as captured through the medical and hospital bills submitted to L&I for State Fund claims; and (B) the duration of absence from work, as captured through: the return-to-work (RTW) dates noted by claim managers and ourselves in our COVID-19 surveillance system and/or the total number of paid time loss days.

As shown in Figure 1, of the 12,376 claims in the base cohort (COVID-19 claims with a positive test and exposure at work), 1,673 claims had at least 28 days of estimated symptom duration and were labelled as suspected PCC cases, and a mostly random 50% sample of the suspected cases were manually reviewed (N = 835 claims). The sample was not truly randomness because we chose to review all suspected cases with death or disability (N = 36). We were unable to review all suspected cases due limited staff resources. In this review process, we abstracted medical data from the medical visit summaries, activity prescription forms, and other communications between the claimant and L&I. Symptoms or conditions were considered post-COVID conditions so long as the medical provider does not contest its connection with the COVID-19 infection in the medical records. Pre-existing conditions worsening by COVID-19 are considered post-COVID conditions.

If the worker was experiencing one or more symptoms or diseases related to their COVID-19 infection 28 days or more after their confirmatory positive test, then the case is confirmed as PCC (N = 358 claims, 42% of reviewed).

Figure 1. Workflow of Study A



We then build a timeline that pairs symptoms with the current work status and any job modifications. All claims had at least six months' worth of return-to-work information at the time of review, however claims from earlier in the pandemic could have more than two years' worth. We will be comparing the return-to-work timeliness using survival analysis methods within the first six months post-infection, to avoid skewing the results in favor of older claims. Cases are censored when they are lost to follow-up due to claim closure, the worker being terminated, or death.

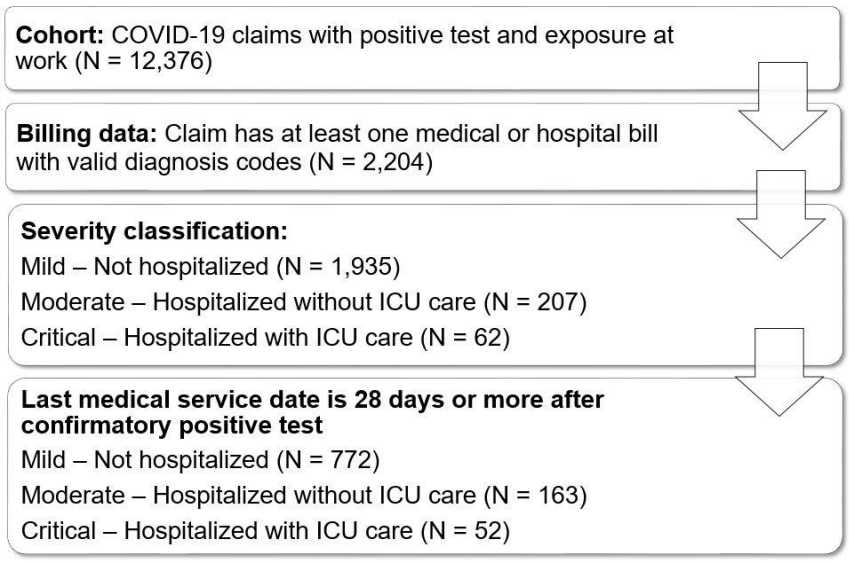
Study B: Estimating Post-COVID Condition Prevalence through Medical Billing Data

In Study B, we used data from medical bills submitted to L&I for reimbursement available for some compensable State Fund claims to estimate symptom duration. This required two assumptions: that the medical visits were all related to the worker's recovery from COVID-19 and that the worker was still experiencing symptoms at the time of service. The ICD-10-CM diagnosis codes were then use to characterize the symptoms.

As shown in Figure 2, from the base cohort of 12,376 claims (COVID-19 claims with a positive test and exposure at work), only 18% had one or more medical bills with at least one valid diagnosis code for medical services at any time after the confirmatory positive test (N = 2,204 claims), and 987 claims had medical services 28 days or more after the confirmatory positive test.

The claims were then grouped into severity classes using the WCIRB methods, with some modifications [8]. Severity is determined through hospitalization and intensive care unit (ICU) admission status. Hospitalization status comes from multiple sources: hospital bills submitted for reimbursement; statements made by the claimant and recorded during the acute COVID-19 surveillance system; or the DOH contact tracing dataset. ICU admission status comes from: the DOH tracing dataset; information collected during case review in Study A; or the diagnosis of conditions that strongly indicate ICU admission (ICD-10 code for dependence on ventilator status (Z99. 11), and ICD-10 procedure codes for the insertion of feeding devices). Non-hospitalized cases are defined as mild. Hospitalized cases without ICU care are defined as severe, while those with ICU care are defined as critical. Incomplete information may lead to the misclassification of critical cases as severe, as ICU admission status information tends to be less complete.

Figure 2. Workflow of Study B



Unlike the WCIRB, we did not use the hospital discharge date as the start date for PCC symptom duration. Instead, as in study A, we use the confirmatory positive test day. If we had used the discharge date, eleven severe cases and two critical cases would be dropped. Unlike the WCIRB, we included fatal claims; there were three fatalities in the mild group, two in the severe group, and one in the critical.

RESULTS OF STUDY A

Estimated Prevalence of Post-COVID Conditions

In this study, we used symptom data abstracted from the claim's medical documentation to determine if the worker had a post-COVID condition. A smaller percentage of self-insured claims were captured as suspected PCC cases compared to State Fund (7% SI vs 17% SF, Table 1). Self-insured claims lack medical billing data, a major source for suspected case identification, and must rely upon the number of paid time loss days and known return-to-work dates. Furthermore, self-insured cases often lacked the medical documents required to confirm symptom duration; 71% of reviewed self-insured cases resulted in a PCC status that was undetermined (Table 2).

Incomplete information was a problem among State Fund claims as well; 27% of reviewed State Fund cases were undetermined (Table 2). Only three reviewed SF claims were undetermined because it was unclear if the provider believed that the symptoms were COVID-related. Overall, 43% of the reviewed cases were confirmed to have at least 28 days of symptoms and therefore meet our case definition for post-COVID conditions.

Table 1. Count of suspected and reviewed cases by claim liability

Liability Group	# Claims in Base Cohort	# Suspected for PCC	# Reviewed
State Fund	7,585	1,317	653
Self-insured	4,791	356	182
Total	**12,376**	**1,673**	**835**

Table 2. Results of case review by claim liability

Liability Group	Confirmed PCC Case (% of Reviewed)	Not PCC Case (% of Reviewed)	Undetermined if PCC Case (% of Reviewed)
State Fund	321 (49%)	154 (24%)	178 (27%)
Self-insured	37 (20%)	16 (9%)	129 (71%)
Total	**358 (43%)**	**170 (20%)**	**307 (37%)**

The estimated prevalence of post-COVID conditions was 6-9% among all COVID-19 claims established between February 2020 and March 2022, with a positive laboratory test and confirmed work-related exposure (Table 3). We calculated upper and lower estimates for the prevalence of PCC, to account for the incomplete nature of our medical records and better describe the burden of disease. We used the following formulas:

- Lower Estimate for # of PCC Cases = Suspected x (Confirmed / Reviewed)
- Upper Estimate for # of PCC Cases = Suspected x (Confirmed / Reviewed excluding undeterm.)

Table 3. Estimated prevalence of PCC through manual claim review

Liability Group	# PCC Cases Lower Estimate	# PCC Cases Upper Estimate	PCC Prevalence Rate Lower Estimate	PCC Prevalence Rate Upper Estimate
State Fund	647	890	9%	12%
Self-insured	72	249	2%	5%
Total	**717**	**1,134**	**6%**	**9%**

There are many other existing case definitions for post-COVID conditions. For example, the WCIRB report and the WHO use a minimum symptom duration of four months as part of their case definitions. We found that 1.9 to 3.2% of cases had at least three months of symptoms, and 1.6 to 2.6% of cases had at least four months of symptoms.

Disability and Fatalities among Confirmed PCC Cases

We chose to review all suspected PCC cases that were fatal or were currently eligible for disability benefits (N=36). There were sixteen fatalities among those suspected for post-COVID conditions, three of which were confirmed to be due to post-COVID conditions. Two fatalities were caused by restrictive lung disease. One fatality was a suicide following a prolonged course of labyrinthitis.

As of the time of reporting, thirteen workers are eligible for permanent partial disability due to PCC and seven workers are eligible for total permanent disability. This includes workers that have not to-date applied for or received disability payouts. A breakdown of the disabling conditions are shown in Table 4. Note that cases can be counted under multiple conditions where applicable.

Table 4. Conditions resulting in partial or total disability among post-COVD condition cases

Disabling condition(s)	Permanent partial disability	Total permanent disability	Total
Deconditioning, weakness, and/or fatigue	2	6	8
Respiratory conditions	2	4	6
Mental health conditions	3	2	5
Other conditions	4	1	5
Cognitive impairments	3	1	4
Cardiovascular conditions	1	1	2
Total unique workers[1]	**13**	**7**	**20**

[1] Workers can be counted under one or more condition

Confirmed Case Characteristics for Confirmed PCC Cases

Confirmed PCC cases (N = 358) were compensable 91% of the time, and accepted 96% of the time. Among compensable confirmed cases, the median claim cost paid-to-date was $6,911 (25% have less than $3,085; 75% have less than $24,383). Among the 88% of confirmed cases with paid time loss, the median number of paid days was 45 days (25% have less than 28 days; 75% have less than 88 days). Since 85% of claims were still open at time of reporting, these values are subject to increase over time. Confirmed PCC cases were 72% female, with a median age of 49 ± 12 years. Five percent of PCC claims were filed in a language other than English. This is probably an underestimate; missing language is assumed to be English by L&I's data systems.

Table 5 describes the prevalence of PCC by various claim characteristics. All differences in prevalence referenced in this section were statistically significant. PCC prevalence decreases by claim established year, in line with published literature suggesting that Delta variants were more likely to result in PCC compared to the newer variants [6]. Prevalence is higher among older claimants, female claimants, and those filing in a language other than English. The worker's industry at the time of injury is reported by North American Industry Classification System (NAICS) industry sector. The "Transportation and Warehousing" sector had the highest prevalence, compared to all other sectors with at least five confirmed cases.

Tables 6 describes the estimated prevalence of PCC by metrics derived from the Department of Health's contact tracing dataset. Approximately 90% of cases were successfully linked with a Department of Health record. Hospitalized cases had a higher estimated prevalence of PCC than non-hospitalized cases. There were no significant differences in prevalence between cases hospitalized with ICU admission and those hospitalized without ICU admission. The contact tracing dataset includes fields for several comorbidities such as diabetes, lung, liver, cardiac, or kidney diseases. The PCC prevalence is higher among individuals with any of the reportable comorbidities, and among individuals reporting diabetes (the only individual comorbidity to have at least five confirmed cases).

Table 5. Estimated PCC prevalence by claim characteristic

Claim Characteristic	# Confirmed Cases (N = 358)	# PCC Cases Lower-Upper Est.	PCC Prevalence Rate Lower-Upper Est.
Claim Established Year			
2020	235	359 - 554	10% - 16%
2021	97	238 - 404	6% - 10%
2022	26	129 - 188	3% - 4%
Claimant Age Range (years)			
18 - 29	29	56 - 100	2% - 4%
30 - 39	61	121 - 209	3% - 6%
40 - 49	77	168 - 285	6% - 10%
50 - 59	122	238 - 345	10% - 15%
60 - 69	64	120 - 162	13% - 18%
> 70	4	*	*
Claimant Sex			
Female	258	495 - 798	6% - 10%
Male	100	218 - 332	5% - 7%
Claimant Language			
English	339	646 - 1010	5% - 8%
Spanish	14	43 - 66	15% - 23%
Other	4	13 - 41	17% - 52%
Sectors with >5 confirmed cases			
Admin., Support, Waste Mgmt, Remediation Serv.	18	34 - 46	7% - 10%
Agricult., Forestry, Fish. and Hunt.	6	15 - 22	9% - 14%
Educational Services	45	79 - 104	7% - 9%
Health Care and Social Assistance	221	414 - 682	6% - 10%
Public Administration	39	91 - 142	4% - 5%
Retail Trade	7	15 - 27	7% - 13%
Transportation and Warehousing	5	24 - 33	21% - 30%

*Suppressed due to insufficient data to derive stable estimates (less than 5 confirmed PCC cases).

Table 6. Estimated PCC prevalence by claim Characteristics from WC Data and DOH Data Linkage

Claim Characteristics from DOH Contact Tracing	# Confirmed Cases (N = 358)	# PCC Cases Lower-Upper Est.	PCC Prevalence Rate Lower-Upper Est.
Claimant Ethnicity			
Not Hispanic or Latino	150	245 - 380	8% - 13%
Hispanic or Latino	29	62 - 108	9% - 16%
In DOH, ethnicity unknown	144	323 - 509	5% - 8%
No DOH match	35	81 - 129	4% - 6%
Claimant Race			
Non-Hispanic White	124	230 - 334	6% - 9%
Non-Hispanic Native Hawaiian or Other Pacific Islander	9	12 - 19	10% - 15%
Non-Hispanic Multiracial	7	10 - 16	9% - 15%
Non-Hispanic Black	23	41 - 84	6% - 12%
Non-Hispanic Asian	37	56 - 95	10% - 17%
Non-Hispanic American Indian or Alaska Native	2	*	*
Hispanic	38	80 - 134	8% - 14%
In DOH, race unknown	79	192 - 295	5% - 7%
No DOH match	35	81 - 129	4% - 6%
Hospitalized according to DOH			
Yes	64	119 - 175	32% - 48%
Not reported	259	516 - 828	6% - 8%
No DOH Match	35	81 - 129	4% - 6%
Hosp with ICU Care according to DOH			
Yes	14	22 - 23	36% - 38%
Not reported	274	613 - 983	6% - 10%
No DOH Match	35	81 - 129	4% - 6%
Has any Comorbidities			
Yes	49	568- 906	14%- 20%
Not reported	274	81- 129	6%- 10%
No DOH Match	35	67- 101	4%- 6%
Diabetes			
Yes	32	50- 64	20%- 26%
Not reported	291	584- 939	6%- 10%
No DOH Match	35	81- 129	4%- 6%

*Suppressed due to insufficient data to derive stable estimates (less than 5 confirmed PCC cases).

Return to Work for Confirmed PCC Cases

Among all PCC cases (N = 358), 94% of cases were still off work after 28 days of illness, where day 0 is the confirmatory laboratory test date. At 60 days of illness, 54% of cases were still off work. Hospitalized cases had a significantly slower return-to-work (Kaplan-Meier p-value < 0.001), with 76% of cases still off work after 60 days of illness. And at six months post-infection, where our results must cut-off for standardization, 47% of hospitalized cases remained off work compared to 24% of never hospitalized cases. We found no significant differences when comparing return-to-work by ICU admission status for hospitalized workers (KM p-value = 0.08), gender (KM p-value 0.48), Healthcare & Public Administration sectors vs. all others (KM p-value = 0.88), or State Fund vs. self-insured (KM p-value 0.09).

After returning to work, 17% of confirmed cases required a reduction in hours or number of shifts per week and 12% required modified duties. Modified duties include sedentary tasks only, no direct patient care for healthcare staff, increased breaks, no heavy lifting, and telework.

We observed that 4% of confirmed cases attempted a return to work but were taken off duty again due to post-COVID symptoms. In these instances, the worker or their provider may have overestimated their current ability to work, or the light duty provided by the employer had exceeded the worker's current capacity.

Symptom Frequency and Duration for Confirmed PCC Cases

Using the available medical records, we built a timeline of symptoms for the reviewed confirmed PCC cases. We were able to construct symptom timelines for 333 out of 358 confirmed cases. In the remaining 25 cases, letters from the provider or activity prescription forms attested that the worker had a post-COVID condition, but specific dates weren't provided for the onset and/or end of symptoms.

We find that the administrative data used to identify suspected cases overestimates the true symptom duration by a median of 6 days and the correlation between the two measures is fairly good (R-squared value of 0.79). An overestimate is preferable, as it means that we likely did not exclude significant numbers of true PCC cases by using the administrative data as a proxy in the initial steps.

The most common symptoms reported at any point in the illness were unsurprising – cough, fatigue, dyspnea, headache, and fever (Table 7). These are mostly acute phase symptoms, with their onset starting in the first week of illness. However, fatigue, dyspnea, chest pain, and muscle weakness tend to continue into the post-COVID period (28 days or more since positive test). Among workers reporting a cough after 28 days, 72% were off work for at least one day in this period. Employers may require workers with a cough to remain at home to reduce the transmission of disease, though the worker was otherwise able to work. Workers with muscle weakness and dyspnea often required job modifications, such as increased breaks and reduced hours, when they returned to work.

Complicated pulmonary and cognitive condition tend to have the longest durations. Restrictive pulmonary disease, sleep apea, pulmonary fibrosis, and cognitive impairments have median duration of

over 300 days. Mental health conditions such as depression and anxiety were reported by 20% of confirmed cases.

Table 7. Top 10 most common symptoms reported by confirmed PCC cases at any point in the illness

Symptoms	# Cases	Median Start Day (Days since test)	Median End Day (Days since test)	% Off Work After 28th day*	% Work Restricted After 28th day*
Cough	337	0	21	72%	10%
Fatigue	283	7	50	48%	15%
Dyspnea	256	2	36.5	57%	15%
Headache	243	-1	15	45%	15%
Fever	229	-1	10	85%	3%
Myalgia	173	0	13	62%	12%
Dyspnea	115	27	64	49%	18%
Chest Pain	111	10	38	61%	12%
Muscle weakness	109	12	32	66%	21%
Chills	87	0	8	93%	0%

* Worker was kept off work or worked with restrictions for one or more days after the 28th day of illness.

RESULTS OF STUDY B

Estimated Prevalence of Post-COVID Conditions

In this secondary study, we used the service dates associated with workers' medical bills to estimate the symptom duration and determine if a worker had a post-COVID condition. Among the 12,376 claims in the cohort, 2,204 (18%) have one or more medical bill with a valid diagnosis code. Claimants with bills for services occurring 28 days or more after the confirmatory positive test date are presumed to have a post-COVID condition, based on the assumption that the medical visit was related to the worker's recovery from COVID-19 and that the worker was still experiencing symptoms at the time. Forty-five of claims with medical bills meet this criteria (Table 8). As expected, a greater percentage of severe and critical claims had medical services 28 days or more after the positive test (Table 8).

Table 8. Summary statistics on medical services captured through billing data, by severity group

Severity	Total Claims	Claims receiving treatment after 28d	Claims receiving treatment after 4 months
Mild : Not hospitalized	1935	772 (40%)	267 (14%)
Severe : Hospitalized	207	163 (79%)	93 (45%)
Critical : Hosp. with ICU	62	52 (84%)	37 (60%)
Total	**2204**	**987 (45%)**	**397 (18%)**

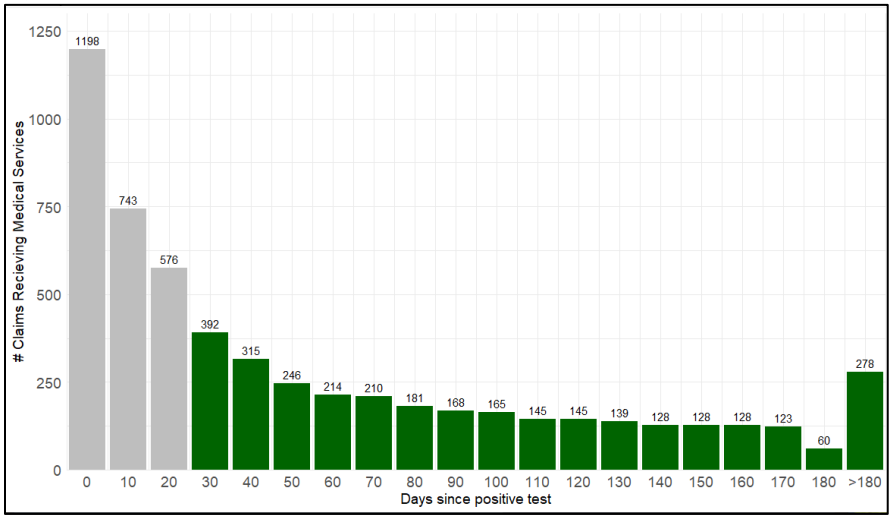
The estimated prevalence of post-COVID conditions indicated in medical billing data was 24-45% among all COVID-19 claims established between February 2020 and March 2022, with a positive laboratory test and confirmed exposure at work (Table 9)**.** Our upper estimate is the percentage of claims with medical bills that are receiving medical services 28 days or more after the confirmatory positive test (N = 987, 45%). To arrive at the lower estimate, we revised down the upper estimate by 54%, which was the percentage of claims with medical billing data in study A that were confirmed to be PCC cases. The remaining 46% of claims from study A either had insufficient medical information to determine PCC status or we found that the medical bills from after 28 days were for injuries unrelated to COVID-19. The PCC prevalence in study B is greatest among critical cases (68-84%) than severe cases (52-79%) than mild cases (19-40%).

Table 9. Upper and lower estimates of PCC derived from medical billing data in study B

PCC Severity	Study A: % of abstraction-confirmed PCC cases that have med. bills	Study B: PCC Prevalence from med. bills alone	Study B: PCC prevalence adjusted by the ratio of abstraction-confirmed PCC cases in Study A
Mild : Not hospitalized	49%	40%	19%
Severe : Hospitalized	66%	79%	52%
Critical : Hosp. with ICU	81%	84%	68%
Total	**54%**	**45%**	**24%**

Figure 3 shows the number of claims receiving medical services per day since the positive test. We expected a much greater number of claims to be receiving treatment during the acute phase (< 28 days) than after, with a faster drop-off after 28 days.

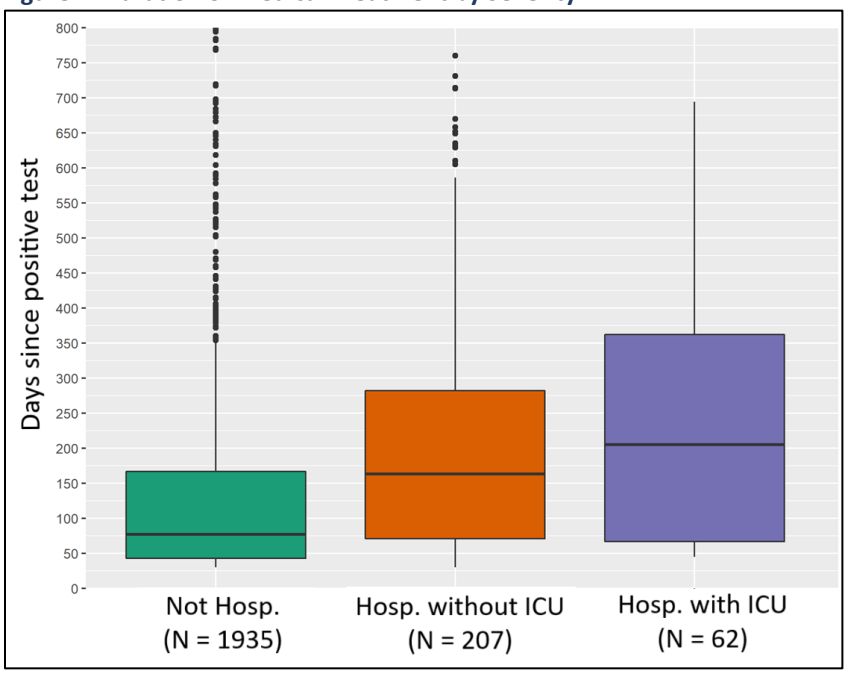
Figure 3. COVID-19 claims receiving medical services according to billing data



Out of the 7,769 bills for services in the first 28 days of illness, 25% are from in-patient hospitalizations and 55% belong to claims that will go on to be categorized as PCC. The majority of hospitalizations occurred in the within the first 28 days of illness, however several claims had hospitalizations after several months of illness.

The total duration of medical treatment – days between the positive test date and the last bill at the time of reporting– increases by severity group (Figure 4). Mild cases have a median duration of 74 days of treatment; severe cases have a median of 172 days; critical cases have a median of 302 days. Each group has a large spread of durations with many outliers, especially among mild cases. Note that 85% of cases were still open at the time of reporting; cases had at least 9 months' worth of data, however we'd expect the median duration to increase over time.

Figure 4. Duration of Medical Treatment by Severity



Most Common Diagnoses in Medical Billing Data

The ICD-10-CM diagnoses for PCC cases were very diverse; there were 1,170 unique full ICD-10-CM codes in the medical billing data, with an average of 5.5 diagnosis codes per case. Respiratory failure and pneumonia features prominently among severe and critical cases (Table 10).

Table 10. Most common ICD-10-CM diagnosis codes in medical bills for PCC cases

	# Claims
Mild PCC Cases	
R06.02 - Shortness of breath	153
R53.83 - Other fatigue	93
R07.9 - Chest pain, unspecified	76
R50.9 - Fever, unspecified	60
R06.00 - Dyspnea, unspecified	54
I10 - Essential (primary) hypertension	50
R07.89 - Other chest pain	45
R00.0 - Tachycardia, unspecified	37
R00.2 - Palpitations	35
R42 - Dizziness and giddiness	34
Severe PCC Cases	
J96.01 - Acute respiratory failure with hypoxia	100
R06.02 - Shortness of breath	92
R91.8 - Other nonspecific abnormal finding of lung field	64
J12.89 - Other viral pneumonia	64
R09.02 - Hypoxemia	61
I10 - Essential (primary) hypertension	55
R06.00 - Dyspnea, unspecified	43
J18.9 - Pneumonia, unspecified organism	38
R50.9 - Fever, unspecified	37
E87.6 - Hypokalemia	33
Critical PCC Cases	
J12.89 - Other viral pneumonia	18
J96.01 - Acute respiratory failure with hypoxia	17
R06.02 - Shortness of breath	14
R91.8 - Other nonspecific abnormal finding of lung field	12
I10 - Essential (primary) hypertension	11
J80 - Acute respiratory distress syndrome	11
R09.02 - Hypoxemia	10
J18.9 - Pneumonia, unspecified organism	10
J96.90 - Respiratory failure, unspecified whether with hypoxia or hypercapnia	10
E78.5 - Hyperlipidemia, unspecified	9

Eighteen claims in the cohort had the diagnosis code for dependence upon a respirator (Z99.11); three claims had this diagnosis after the 28th day of illness. Eighty-one percent of critical PCC cases had the diagnosis of acute respiratory failure with hypoxia (J96.01), while only 55% of severe and <1% of mild PCC cases did. Acute respiratory distress syndrome (J80) was diagnosed in 52% of critical PCC cases and 13% of severe PCC cases.

COMPARISON OF RESULTS FROM STUDY A AND STUDY B

The base cohort of study A and study B were the same – COVID-19 claims with sufficient evidence of a work-related exposure, with a positive test, and established at least 6 months before case review began (e.g. between 2/1/2020 and 3/31/2022, N = 12,376 claims). The two studies differ in how the symptom duration was determined, and from that, what percentage of claims had at least 28 days of symptoms. In study A, the symptom duration was determined using manual case review and abstraction of medical data from the claim documents. This was done for 50% of suspected cases. The resulting PCC prevalence estimate was 6-9% of all COVID-19 claims in the base cohort. In study B, the symptom duration was determined using the service dates found in medical billing data, which was available for 18% of claims in the base cohort. The resulting PCC prevalence estimate was 24-45% of all COVID-19 claims with medical billing data.

Limiting the cohort to only those with medical billing data in study B had profound effects on the prevalence estimate. If we were to similarly restrict the cohort of study A to only claims with billing data, the estimated prevalence of study A would increase to 27-36%, much closer to the results of study B. Compared with all COVID-19 claims, claims with medical billing data have a higher median number of paid time loss days, median age, hospitalization, and non-English filing (Table 11). These factors were associated with higher PCC prevalence rates both studies. There were no differences in the percentage of claims accepted or the gender ratio.

Table 11. Comparison of characteristics of claims included in study A and B

Study Cohort	Median Paid Time Loss (Days)	Median Age (Years)	% Hospitalized	% Filed in language other than English	Median Symptom duration among confirmed cases (Days)
A	11	40	4%	3%	30
B	20	44	18%	7%	43

Comparing the most common symptoms identified in study A and B, we observe that certain symptoms such as cough are not well-represented in the medical billing data. While not a primary concern for some patients, it can cause additional problems such as sleep impairment and the inability to work due to employer concerns of disease transmission. Symptoms that are well-represented in both studies are fatigue, dyspnea, chest pain, and symptoms associated with hospitalization. Tachycardia appears to be more common in the medical billing data than the abstracted medical records.

DISCUSSION

Estimated Prevalences

In this project, we used two methods for arriving at an estimated prevalence of occupational post-COVID conditions, defined as 28 days of symptoms after the confirmatory positive test among individuals with a history of SARS-CoV-2 infection attributed to work. In study A, we manually reviewed cases suspected for post-COVID conditions to determine the duration of symptoms and study the return-to-work process. The estimated PCC prevalence in study A was 6-9% of all workers' compensation COVID-19 claims. Study B replicated some of the methods of a WCIRB study using medical billing data, and found an estimated PCC prevalence rate of 24-45% among all workers' compensation COVID-19 claims with medical billing data.

We feel greater confidence in the 6-9% prevalence estimate from study A, and believe that selection bias in study B resulted in an overestimated prevalence. The only difference between the two cohorts was that study B required at least one medical bill submitted to L&I. The resulting cohort was more likely to be hospitalized, had greater time loss, and had higher rates of known risk factors for PCCs compared to study A. Non-hospitalized workers were best captured and described by the methods of study A. These workers also experienced prolonged COVID symptoms, reduced hours, modified duty, and time-loss and are important to our understanding of PCCs.

Comparison with External Research

Methodology and case definition has a strong impact on the PCC prevalence estimate. Studies using the self-report of symptoms tend to find higher prevalences compared studies done in clinical settings [7].

At one month post-infection, the CDC estimates that 13% of all COVID-19 cases have a post-COVID condition [1]. This is slightly higher but directly comparable to our prevalence estimate of 6 to 9% from study A, at 28-days post-infection. At three months post-infection, the CDC estimates that 2.5% of all COVID-19 cases continue to experience post-COVID conditions [1]. Similarly, in study A we estimated a PCC prevalence at three months post-infection of 3-5%, using the constructed symptom timelines. Our research appears to underestimate the number of PCC cases with shorter durations, but are roughly in-line with the CDC on the longer lasting PCC cases. Given the profound differences between all PCC studies, we will not be drawing firm conclusions from these slight differences.

The WCIRB report that we have partially replicated here found the following rates in the Californian workers compensation system: "Cumulatively over a four-month post-acute care period, about 11% of workers with mild infections received medical treatments for long COVID symptoms in the workers' compensation system, while the share was higher for workers with severe (36%; hospitalization without ICU care) or critical (40%; hospitalization with ICU care) infections" [8]. Neither our data sources or methods are directly comparable, however we find relatively similar prevalence rates among the cohort of study B with at least four months of medical treatment: 7-14% among mild cases, 30-45% among

severe cases, and 48-60% among critical cases. Among the cohort of study A, only 2-3% of COVID-19 claims will go on to have at least four months of symptoms.

PCC Case Definition

In the development of our case definition, we had to make decisions that results in a cohort favorable to our limited resources but potentially omitting certain groups of claimants. Early in the pandemic, access to laboratory testing was limited and if available, only available to healthcare workers and first responders. By requiring a positive laboratory test, we may be excluding workers infected with the Delta variant, which peaked in our data in the fall of 2021 at a time when rapid tests were used with high frequency. People infected with the Delta variant have been shown to be at higher risk for post-COVID conditions. Including both open and closed claims was important to us, as the most severe PCC claims may remain open for several years and omitting these would bias in favor of less severe cases.

The minimum symptom duration used in our case definition (28 days) is not clinically relevant, and other organizations are using alternative minimum durations; for example the World Health Organization (WHO) uses four months. Applying the WHO case definition to our cohort would result 39% fewer cases, for a prevalence of 2-3%. We chose to use 28 days to align ourselves with statements made by the CDC, and to create the opportunity to review a wide variety of claim scenarios to identify possible biases in our methods. An overly restrictive case definition would result in only the most clear-cut PCC cases being reviewed. Meanwhile, milder PCC cases with symptom durations that in actuality met the case definition could get lost in the administrative barriers of the workers' compensation system. Future research may either: (A) alter the symptom duration to meet other groups' activities; or (B) create a two-step system in which the 28 day threshold is used to flag suspected claims for review, while a higher threshold is used to confirm the case as PCC.

Rejected claims are a valuable source of information despite often lacking sufficient medical records, because there are many administrative reasons as to why a claim may be denied, such as incomplete paperwork or filing self-insured claim through the State Fund system. Our goal is to estimate the overall burden of disease with as few administrative biases as possible. In this study, at least ten confirmed PCC cases were rejected; three due to administrative reasons.

Data Quality

Missing administrative data made it complicated to estimate the duration of symptoms. State Fund claims tend to have more complete data than self-insured, who are required to report less information to L&I. Accepted claims are more complete than claims rejected early on in the process. Claimants who received time loss benefits during their illness have more data than those who were kept-on-salary. To account for all of these differences – and not bias the cohort towards one type of claim – we explored many potential pathways to capture claims. Each pathway had strengths and weakness. We found too many false positives when we relied upon free-text fields, such as the return to work dates entered in by claim managers and research staff. A typo in the month or year could surpass the 28-day cut-off for suspected PCC cases. When looking for a rare condition in large datasets, false positives can easily

outweigh true positives. Despite several rounds of query optimization, 20% of reviewed cases were found to be false positives.

While time intensive and not complete, the manual review process was a critical piece of our research to counteract data quality issues. The pandemic complicated employment in a myriad of ways, so relying upon time loss days as a certain indicator of post-COVID illness would be a mistake. There are many reasons as to why a worker was kept off of work during the pandemic, such as facility closures and quarantine restrictions from sick coworkers or household members. We find that the administrative data slightly overestimates the true symptom duration by a median of six days. The accuracy of this estimate dramatically improved as we optimized the methods for our data source.

Several extenuating factors impacted the quality of our industry-level reporting. About half-way through our study period (May 2021), Washington's Health Emergency Labor Standards Act extended presumptive coverage for COVID-19 to frontline workers. Frontline workers were broadly defined, and included workers in food and meatpacking, transit, childcare, retail, lodging, restaurant, education, and public libraries [10, 11]. Before HELSA was enacted, Washington's governor proclamation ensured that healthcare workers and first responders were eligible for medical benefits and wage replacement during quarantine, provided certain criteria were met. Workers in occupations not covered by the governor's proclamation or presumption laws had to meet a higher burden of proof to have their claims accepted and may be dissuaded from filing in the first place. The Healthcare and Public Administration sectors have a lower prevalence of PCC compared to all other sectors (5-9% HC/PA vs. 11% all other). The difference could be explained by a greater number of claims for milder illnesses filed by Healthcare and Public Administration workers, however the median number of paid time loss days and the median duration of symptoms was equivalent across these two groups. When manually reviewing cases in study A, we made efforts to gather observations from diverse industries, reviewing at least five cases from each sector. Ultimately, the Healthcare and Public Administration sectors collectively made up 70% of all claims reviewed in study A. Other considerations when drawing conclusions from industry-level data is that healthcare workers can be found in the "Administration, Support, Waste Management and Remediation Services" sector, which includes contracted workers in nursing home facilities, and the Education sector, which includes a very large teaching hospital.

The percentage of claims with a linkage to our state Department of Health's contact tracing data has decreased gradually over time, as contact tracing efforts scale back and at-home testing proliferates. The percentage of COVID-19 claims suspected for post-COVID conditions with a DOH match decreases from 93% of claims established in 2020 to 80% of claims established in 2022. This is a particular limitation for the analysis of hospitalization variables. In study B, which relied upon the Department of Health's data on ICU status for the severity groupings, it is possible that we misclassified claims which should have been in the severe or critical groups. This would have the effect of overestimating the prevalence of PCC in the mild group and underestimating the prevalence in the severe and critical groups.

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