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Post-Acute COVID Among California Workers' Compensation Claims Filed in 2020-2022

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Running Head Title (50 ch including spaces): PASC Among California WC Claims 2020-2022

Structured Abstract

Objectives: To examine sociodemographic risk factors for post-acute COVID (PASC) among California workers' compensation (WC) claims in 2020-2022.

Methods: We matched WC claims to SARS-CoV-2 test data, augmented with external sociodemographic data, and estimated odds ratios (OR) using logistic regression models.

Results: PASC accounted for 7% of the 206,375 COVID and PASC cases. PASC cases were more commonly 30-49 years old, female, longer tenured, and in healthcare and protective service occupations compared to acute COVID. The highest PASC OR were among workers 50-69 years old, and workers of color, including non-Latino American Indian/Alaska Native, Black, Native Hawaiian/Pacific Island, and multiple races, and healthcare practitioners.

Conclusions: During the first three years of the COVID pandemic, PASC was common among workers with WC claims in CA and unevenly distributed, with observed disparities by age, race, and occupation.

Keywords – post-acute COVID-19; occupational health; workers' compensation; long COVID; sociodemographic factors

Learning Outcomes

- Describe post-acute COVID-19-related California workers' compensation claims filed during 2020-2022 by main sociodemographic factors, such as race/ethnicity, union representation, health coverage, and income
- State the top five post-acute COVID (PASC) cases by occupation
- Explain which sociodemographic factors are associated with PASC cases

Introduction:

Workplace outbreaks of COVID-19 highlighted workers in close contact with others had an increased risk of SARS-CoV-2 infection.[1] In 2020, California enacted COVID-19 workers' compensation (WC) presumptions that classified COVID-19 infections as work-related among certain frontline occupations, including healthcare workers, as well as among workplaces with outbreaks. As a result, California COVID-19 WC claims filed in 2020 were mainly among health care occupations. Furthermore, jobs for WC claims that involved very close physical proximity and high physical activity tended to cluster within the same employer over a short period, suggesting an aerosol transmission mechanism.[2] COVID-19's presence in California workplaces [3] raises concern about the potential for persistent symptoms among workers. [4] Long COVID, also known as post-acute sequelae of COVID (PASC), refers to a spectrum of symptoms lasting more than four weeks following a SARS-CoV-2 infection. Despite the clear impact of work on COVID-19 transmission, little attention has been given to PASC among workers.

Evidence using surveys and workers compensation claims highlights disparities among PASC by occupation group. An analysis of US Behavioral Risk Factor Surveillance System (BRFSS) showed higher PASC prevalence among education and social care, police and protective services, hospitality, and transportation occupations.[5] In an analysis of New York COVID-related claims, researchers found nearly one-third were PASC, mainly among healthcare, law enforcement, and public administration industries.[6] In Wisconsin, Modji et al. found that workers in manufacturing and public administration were more likely to develop PASC compared to healthcare workers.[7] WC claims data represent a unique opportunity to

examine COVID-19 in the context of work, as medical billing data paired with industry and occupation information provide insights that other datasets do not.

Unionization, insurance status, and injury severity may affect WC claim filing patterns, alongside presumption laws. Unions may enhance health and safety programs in workplaces leading to better health outcomes. [8] Unionized workers may also be provided guidance throughout the claims process and may have fewer fears of retaliation than non-unionized workers.[9, 10] Conversely, fear of reprisal or job loss may be heightened for those in precarious work environments. Employers who offer health insurance are more likely to have injured workers who file claims.[11] Finally, workers with acute, severe injuries may be more likely to file claims, whereas workers with chronic illnesses may delay or not file a claim.[12]

The relationship between PASC and factors that could influence workers' compensation claims remains unclear at this time. To address this knowledge gap, our study aims to characterize PASC among WC claims in California from 2020-2022 and assess sociodemographic factors associated with PASC cases.

Methods:

Data were extracted from the California Workers Compensation Information System (WCIS) system on March 13, 2024 using any of the following criteria: 1) keywords within the injury description (e.g., “COVID” or “CORONA” or “SARS” or “CV”), 2) COVID-19 International Classification Disease code version 10 (ICD-10) (U07.1 or U07.2) or long COVID-related codes (U09.9 or B94.8) within the medical billing data, 3) nature of injury codes related to COVID-19 (83) and 4) cause of injury codes related to pandemic (83). All claims, regardless of whether a claim was accepted or denied, were included in the analysis. Because time from injury to last billing date was part of our PASC case definition, we excluded claims based on

their injury date (prior to January 1, 2020 and after December 31, 2022) or if the nature of injury, part of body, or cause of injury codes reflected a physical or traumatic injury (see Appendix, http://links.lww.com/JOM/C566 for list of codes) (Figure 1).

Each WC claim included demographic information (age, sex, date of hire), the date of injury, zip code where the injury occurred, employer name, employer address, an injury description text field, industry codes, occupation free text, and medical billing information. Tenure, categorized as five-year age groups, was created based on date of hire. We assigned claims as metropolitan (rural or urban commuting area (RUCA) Codes: 1–3) or nonmetropolitan (RUCA Codes: 4–10) based on the injury zip code, using the US Department of Agriculture's RUCA codes.[13] We also identified 'clusters' of two or more claims occurring within a specific worksite during a three-week period. Briefly, a 'large cluster' binary variable was created to pinpoint claims that were a part of a cluster of 21 or more claims. Details of the clustering approach are described elsewhere.[2]

Occupation

We used the National Institute for Occupational Safety and Health's (NIOSH) Industry and Occupation Computerized Coding System (NIOCCS), to obtain census industry and occupation codes for each claim.[14] We used free-text occupation descriptions as occupation text and each claims' provided North American Industry Classification System (NAICS) classification descriptions as industry text for coding claims followed by manual review of a portion of the claims with discrepancies detected during cleaning (8%). Codes were grouped into major occupation group categories using the Census Occupation Codes (COC) (2018 schema).

Demographic and Socioeconomic Variables from External Data

Race/Ethnicity and Test Positivity

Claims data were matched to any California SARS-CoV-2 test record within the California SARS-CoV-2 Test Registry by first and last name, date of birth or age, sex at birth, address, phone number, and injury zip. From matched data, we extracted test results within 15 days of the injury date, race, and ethnicity. Race and ethnicity were further combined into eight categories: Latino, non-Latino (NL) American Indian/Alaska Native (AI/AN), NL Asian, NL Black, NL Multiple Races, NL Native Hawaiian/Pacific Islander (NH/PI), NL Other including multiple races and NL White.

Union Representation and Insurance Coverage

National estimates of union representation and current health insurance status proportions by major occupation group were obtained from the US Census Bureau's Current Population (CPS) Survey Annual Social and Economic Supplements obtained each March from 2020 - 2022.[15-17] Using "On this job, is ... covered by a union or employee association contract?", we created a binary variable coded as yes if the occupation group's percentage of workers represented by a union was greater than the estimate of all workers represented by a union (12.1% in 2020; 11.6% in 2021; and 11.3% in 2022). Using the "Currently covered by health insurance coverage" question, the percentage of individuals insured by an occupation group was coded as "yes" if the group's percentage of workers with health insurance was greater than the average for all workers. This average was 91.2% in 2020, 90.9% in 2021, and 91.5% in 2022.

Income

Estimates of mean annual wages in California by Standard Occupational Classification code (SOC) for 2020-2022 were obtained from Bureau of Labor Statistics Occupational

Employment and Wage Statistics.[18] The means were translated from 2018 SOC codes to 2018 COC. When multiple SOC codes mapped to a single COC, the average of the component occupations' mean wages was calculated. For each year, there were between 121-127 COC codes whose income estimates were generated by averaging multiple SOC code estimates. For these COC codes, between 2-35 SOC-level income estimates were averaged to produce a single COC-level estimate. Wage estimates may vary substantially within a COC comprised of multiple SOC occupations; therefore, the resulting COC income estimates should be interpreted as crude approximations.

Outcome Case Definitions

Once exclusions were applied (see Appendix, http://links.lww.com/JOM/C566 for the list of codes), we classified claims as either an acute COVID claim or a PASC claim using information from medical billing. Using the claim's date of injury or the first date of test linked to the claim number, we calculated the length of time between the injury/test date and the most recent date of service from the medical billing (excluding pharmacy visits or a follow-up visit for a physical or traumatic injury e.g. meeting our exclusion criteria). Acute COVID was defined as either the presence of a COVID-19 diagnosis (ICD-10: U07.1 or U07.2) or a confirmed positive test within 15 days of the claim's date of injury consistent with the CSTE definition of COVID-associated hospitalizations.[19] PASC was defined as presence of a long COVID-related diagnosis (ICD-10: U09.9 or B94.8) or the existence of a claim with a last medical billing date greater than four weeks from the injury date. Otherwise, the claim was considered all other COVID-related, these claims included COVID exposures that did not meet the definition of an acute COVID (no diagnosis or lab test within 15 days) or PASC claim (no diagnosis or claim service greater than four weeks from the injury date).

Finally, we identified unique claimants using first name, last name, social security number (if available), and birth date. If a claimant had multiple claims in the dataset, we selected the PASC claim with the earliest date of injury for analysis (PASC case). If the claimant had no PASC claim, we selected the earliest acute COVID claim or COVID-related claim. The final analytic dataset included 293,290 claimants with race/ethnicity composition available for 57.7%.

Statistical Analyses

We assessed the relationship between each variable and the PASC outcome using logistic models. Occupation and PASC were also assessed by accounting for demographics, tenure, urbanicity, union representation, health insurance, income, and clustering (full model). Recognizing the potential for variation among the major occupation groups, we conducted mixed-level logistic models, both null and full models, with occupation major group as a random effect. Model results were calculated as adjusted odds ratios (OR) and 95% confidence intervals (CI).

All data were analyzed using R 4.5.0.[20]

The California Department of Public Health Occupational Health Branch has a Memorandum of Understanding with the Department of Industrial Relations Division of Workers' Compensation to analyze claims for purposes of public health surveillance. This study is public health practice carried out as part of routine surveillance for COVID response, not research, and is exempt from institutional review board per the California Health and Human Services Agency's Committee for the Protection of Human Subjects.

Results:

We found 293,290 unique claimants including acute (65.3%, n=191,571), PASC (5.0%, n =14,804,) and all other COVID related (29.6%, n=86,915). PASC cases comprised 7% of the

overall among claimants who had COVID, excluding all other COVID-related. Compared to all claimants with acute COVID, the proportion of PASC cases was higher for those 50-69 yr (33.2%, Δ: +9.9%), for females (52.5%, Δ: +6.1%), for longer tenure (10+ years) (42.2%, Δ:+12.7%), among those with self-insured employers (70.6%, Δ: +16.9%), and those at work sites in micropolitan/rural areas (8.4%, Δ:+1.5%) (Table 1). Compared to the acute COVID cases, fewer PASC cases were among Latino workers (29.9%, Δ: -4.9%), shorter tenured workers (< 10 years) (55.9%, Δ: -11.8%), and for work sites in metropolitan areas (91.3%, Δ: -1.0%). The PASC cases also had a larger share of union representation and health insurance compared to acute COVID cases. The PASC workers' average income was 12% higher than acute COVID workers.

The largest number of PASC cases was among healthcare practitioners and technical occupations (26.1%), followed by protective service (24.1%) (Table 2). Although substantially lower in number of cases, these occupation groups had the next highest share of PASC: health care support (8.8%), office and administrative support (7.2%), management (3.4%), building, grounds cleaning and maintenance (2.5%) and production (2.1%). Of PASC cases with racial/ethnic information (Figure 2), we note the highest proportions within each occupation groups: White, Latino, and Asian workers among healthcare practitioners and technical occupations (31.4%, n=779; 30.6%, n = 759; and 22.7%, n=562, respectively); Latino and White workers among protective service occupations (44.4%, n=989 and 34.7%, n=772, respectively). While fewer PASC cases, Latino workers comprised a large share of the farm, forestry and fishing occupational group (89.8%, n= 44). Although Black, AI/AN, and Multiple Race healthcare practitioners were the most common workers within each of their respective racial/ethnic groups, these racial/ethnic group of workers were less represented within the

healthcare practitioner occupational group: Black (5.7%, n=142), AI/AN (0.5%, n=12) and Multiple Race workers (1.9%, n=48).

Being female, 50-69 years of age, of NL Multiple Races and NL NH/PI, of tenure 5 years or more, and working in micropolitan/rural areas alone were each modestly associated with being a PASC case. Union representation and health insurance alone were each strongly associated with being a PASC case. When controlling for other variables, we found nearly 20% higher odds of being a PASC case for female, older (70+ years), and Latino workers along with workers in micropolitan/rural areas (Table 3). The highest PASC OR were among workers 50-69 yrs of age, workers of color including NL AI/AN, Black, Native Hawaiian/Pacific Island, and Multiple Race workers. We also observed elevated ORs for those of advanced tenure (10-20+ year range). Union representation resulted in nearly 15% lower odds of being a PASC case in the full direct model and moved towards the null when major occupational group was included in the model as a random effect.

When we examined PASC in relation to occupational group, we found the highest OR was among healthcare practitioners and technical occupations (OR: 3.33, 95% CI: 1.75-7.37), followed by protective service (OR: 2.18, 95% CI: 1.15-4.83), education, training and library (OR:1.52, 95% CI: 0.78-3.44) and health care support occupations (OR: 1.48, 95% CI: 0.61-4.85) (Figure 3). We also observed elevated odds ratios for these occupation groups: community and social service (OR: 1.45, 95% CI: 0.75-3.25) and management (OR: 1.16, 95% CI: 0.97-1.40). Notably, the major occupational group explained 20.8% of the variance alone when we included the variable as a random effect and 10.9% of the variance for the full mixed-level model.

Discussion:

We found a 7% prevalence of PASC among California workers' compensation acute and PASC COVID cases filed during the 2020-2022 period. The California Workers' Compensation Institute's analysis of 2020-2022 claims found 4.7% were long COVID-related claims involving conditions that hindered or prevented workers from returning to their jobs.[21] Occupation groups deemed "front line" had the highest volume of claims and were found to be associated with PASC cases in our study, consistent with findings from a large US survey.[5] However, public-facing occupations such as education, training, library services, and community and social service were also found to have modestly elevated associations in our analysis similar to findings from the UK.[22]

Our PASC prevalence estimate among acute COVID claimants aligns with other workers' compensation studies and self-reported long COVID survey estimates among adults. According to Howard et al., the prevalence of long COVID ranges between 5-50%.[23] Primary estimates of occupational long COVID prevalence originate from workers' compensation systems that contain data on industry and occupation. State estimates vary from 6-8% in Washington (WA) to 31% in New York.[24, 25] Researchers in WA noted higher prevalence of 24-45% using medical billing data.[24] The prevalence of long COVID and definitions can also vary based on different data sources, source populations, and methods, leading to a range estimates for a working age population. The 2022 National Health Interview Survey (NHIS) found that 6.9% of adults (18 years or older) had long COVID, defined as presence of symptoms lasting three or more months, at some point.[26] Using the same NHIS data, Bonner et al. estimated the US long COVID prevalence among the workforce was 17.8% (95% CI: 16.8-18.9) among those who tested positive for SARS-CoV-2 infection or were diagnosed with

COVID.[27] Cohen and Rodgers found a self-reported long COVID prevalence of 14.3% among US adults using the US Household Pulse Survey data.[28] When Ford et al. analyzed 2022 BRFSS data, they found the prevalence of self-reported long COVID was 6.4% in the US and 5.5% in California among persons 18 years or older.[29] Assessing the prevalence of long COVID among workers has been challenging due to lack of standardized disease definition and routine collection of industry and occupation in infectious disease reporting systems.

Linkage to laboratory testing data offered the opportunity to assess claims by race/ethnicity. The proportion of Latino workers in California with acute COVID claims (34.8%) was commensurate with the 38% of Latino workers in the state according to the CPS in 2020.[30] The percentage of Latino workers with long COVID (29.9%) is also similar to 35.9% Latino adults who developed long COVID, based on US Household Pulse Data.[28] In 2020, California COVID case rates were highest for non-Latino NH/PI adults, followed by Latino, Black, and AI/AN adults.[31] The NHIS survey prevalence also differed by racial and ethnic origins for Latino adults (8.3%) were more likely to ever have long COVID, followed by NL White adults (7.1%), NL Black adults (5.4%), and NL Asian adults (2.6%).[32] More recent evidence from the 2023 California Health Interview Survey indicates a high proportion of Latino adults (44%) experienced COVID-19 symptoms for two months or longer, twice that of White adults.[33] Despite the increase in number of acute COVID WC claims over time for NL-White workers, we found lower estimates (17.6%) of White workers having PASC claims compared to Cohen and Rodgers' prevalence (31.0%).[28]

Most PASC cases in California were found among protective services and health care technicians and technical support workers.[34] These "frontline" occupations also had the highest odds of being a PASC case claimant in these WC data, when accounting for other factors

including union representation and health insurance. At the same time, we also found higher odds of being a PASC case among those working in education, training and library, community and social service, and management. In the UK, Kromydas et al. found that teaching and education, social care, health care, transport and manufacturing or construction industries had the highest likelihood of long COVID using national COVID infection survey data.[22] Silver et al. found that the long COVID prevalence, among those who reported having COVID-19, was highest in drinking establishment and personal care service industries.[4] Despite having the lowest odds of being a PASC case, the food preparation and serving occupation groups had a high frequency of California WC claims in general during the 2018-2022 period which included nature of injury such as strains and contusions along with COVID.[35] Worker filing patterns and contingency labor patterns may create a differential in the types of industries or occupations captured by workers' compensation. For example, few claims were filed in the retail, manufacturing, and warehousing industries [36] despite well-documented early COVID outbreaks. Workers are faced with a complex benefits system to navigate, may fear retaliation [37], and may lack awareness of WC benefits within particular industries [38].

Several other factors may explain these apparent patterns including, but not limited to, COVID presumptions, whether workers have insurance, or are represented by unions. Diagnoses of COVID or PASC unlikely increased WC claims, as presumptions mainly covered acute cases, work attribution mainly relied on these presumptions, and other barriers to WC access remained. Union representation seemed to protect against being a PASC case in our full direct models of WC claims, which supports the hypothesis that this factor may improve overall worker health. When considering occupational group variation, union representation showed a weak association with being a PASC case albeit with wide confidence intervals and not incompatible with an

inverse association. Union stewards may represent many workers and not be adequately trained for assisting workers with injuries or illnesses, as observed by Canadian researchers who conducted a qualitative survey.[39] PASC cases were part of the occupation groups that had higher than the average health care coverage. Health insurance remained a strong association in our analysis when we considered occupational group variation. In contrast, Wuellner and Bonauto recently found use of WC was lower among WA workers with health insurance and those who could not afford medical care.[40] Given the complexity of determining whether long COVID was acquired from a work exposure [41], workers who have health insurance may seek help from their private health care providers.

Workers with PASC may return to work with dysfunctional presenteeism or need assistance re-entering in the workforce.[41] According to analysis from 2022 BRFSS, those with long COVID had 29% increased odds of disability.[27] A systematic review examined return-to-work for those with PASC finding over three in five people return to work 12 or more weeks post-infection.[42] Strategies that support reintegration into the workforce include flexible work arrangements, modified work duties, remote work options and reduced work hours.[43]

Limitations:

Our assessment of workers' compensation data is subject to several limitations. First, these data represent only workers with a PASC claim and do not represent the overall California workforce who have long COVID. Second, occupational misclassification is likely to have been present. While we attempted to assign the best codes where possible, a portion of data may likely have either incorrect occupation or industry codes. Furthermore, more than 10% of claims could not be coded for occupation. We also grouped occupation into major categories for union representation and insurance status variables, which may have introduced addition

misclassification obscuring meaningful differences and attenuating associations. Third, we could not fully link all the records to SARS-CoV-2 laboratory data for extraction of race/ethnicity information. Fourth, we lacked access to all the WC claims for the time-period and could not compare to the non-COVID-related claims. Fifth, we drew from external data by occupation rather than individual-level data on income, whether a worker had health insurance, and union representation. Six, others have found that prior SARS-CoV-2 exposure, vaccine status at first infection, and severity also influence whether a worker might be a PASC case [44]; we did not have access to these variables. Finally, PASC is also likely misclassified because WC claims are administrative data; therefore, dates of bills, medical codes and time of data extract are subject to error or change. Case ascertainment changed over time due to the increased recognition of PASC and changing diagnostic criteria.[45] Acute COVID may have been misclassified because our case definition only linked registry data to WC injury dates within 15 days, even though positive tests could occur after this period. Furthermore, variation is expected given the differing definitions of long COVID – for example, researchers found the prevalence ranged from 4.9-20.9% using five definitions and a California seroprevalence study.[46] Nonetheless our prevalence estimates and findings are consistent with others published WC studies.

Despite these limitations, our analysis demonstrates the extent to which PASC may impact workers with a WC claim including many who could not telework during the pandemic. Many of the workers with PASC are in public-facing occupations or occupations in contact with people with COVID and presence at work. Given the relatively limited treatment available [43], workers with lingering COVID symptoms may need additional workplace accommodations such as shorter workdays, reduced cognitive task complexity, more rest breaks, and flexible work

schedules.[28] California workers with a PASC claim likely represent a smaller share of workers impacted by PASC, given historic underreporting and barriers to WC access.[47] [48]

Conclusions:

Many California workers encountered COVID on the job, and PASC cases represented about one tenth of the COVID and PASC WC cases between 2020 and 2022. WC allows us to understand which industries and occupations are most affected by the longer-term impacts of COVID-19. PASC cases encompass a wide range of industries and occupations, with the highest counts arising from the health care, social assistance, and public administration sectors. Using external data sources, we examined the associations between sociodemographic factors, such as race/ethnicity, union representation and health insurance, and PASC case status. The long-term impact of PASC on work status, medical disability, and treatment will remain an important issue over the years ahead.

References

1. Luckhaupt, S.E., et al., *COVID-19 Outbreaks Linked to Workplaces, 23 US Jurisdictions, August-October 2021.* Public Health Rep, 2023. **138**(2): p. 333-340.
2. Vergara, X.P., et al., *Exposure and Illness Among Workers Filing for COVID-19-Related Workers' Compensation-California, 2020.* J Occup Environ Med, 2024. **66**(10): p. 810-817.
3. Heinzerling, A., et al., *Workplaces Most Affected by COVID-19 Outbreaks in California, January 2020-August 2021.* Am J Public Health, 2022. **112**(8): p. 1180-1190.
4. Venkatesh, A.K., et al., *The association between prolonged SARS-CoV-2 symptoms and work outcomes.* Plos one, 2024. **19**(7): p. e0300947.
5. Silver, S.R., et al., *Prevalence of COVID-19 and Long COVID by Industry and Occupation: Behavioral Risk Factor Surveillance System 2022.* Am J Ind Med, 2025. **68**(1): p. 26-52.
6. New York State Insurance, F., *Shining a light on long COVID: an analysis of workers' compensation data.* NYSIF, 2023.
7. Modji, K., et al., *Long COVID among Wisconsin workers in the workers compensation system: Associations with socio-demographics, vaccination and predominant variant period from March 1, 2020–July 31, 2022.* Journal of Occupational and Environmental Medicine, 2023: p. 10-1097.
8. Leigh, J.P. and B. Chakalov, *Labor unions and health: A literature review of pathways and outcomes in the workplace.* Prev Med Rep, 2021. **24**: p. 101502.
9. Hirsch, B.T., D.A. Macpherson, and J.M. DuMond, *Workers Compensation Recipiency in Union and Nonunion Workplaces.* ILR Review, 1997. **50**(2): p. 213-236.

10. Robinson, A.M. and C. Smallman, *The contemporary British workplace: a safer and healthier place?* Work, employment and society, 2006. **20**(1): p. 87-107.

11. Lakdawalla, D.N., R.T. Reville, and S.A. Seabury, *How Does Health Insurance Affect Workers' Compensation Filing?* Economic Inquiry, 2007. **45**(2): p. 286-303.

12. Premji, S., M. Begum, and A. Medley, *Systemic barriers to reporting work injuries and illnesses in contexts of language barriers.* Am J Ind Med, 2023. **66**(2): p. 122-131.

13. USDA. *2020 Rural-Urban Commuting Area (RUCA) Codes*. 2025 [cited 2023; Available from: https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.

14. NIOSH. *NIOSH Industry and Occupation Computerized Coding System (NIOCCS)*. 2021 [cited 2021; Available from: https://csams.cdc.gov/nioccs/Default.aspx.

15. U.S. Bureau of Census. *Annual Social and Economic Supplements 2020*. 2020 March 26, 2025]; Available from: https://www.census.gov/data/datasets/time-series/demo/cps/cps-asec.2020.html.

16. U.S. Bureau of Census. *Annual Social and Economic Supplements 2021*. 2021 March 26, 2025]; Available from: https://www.census.gov/data/datasets/time-series/demo/cps/cps-asec.2021.html.

17. U.S. Bureau of Census. *Annual Social and Economic Supplements 2022*. 2022 March 26, 2025]; Available from: . https://www.census.gov/data/datasets/time-series/demo/cps/cps-asec.2022.html.

18. U.S. Department of Labor. *Occupational Employment and Wage Statistics (OEWS) Tables*. 2025 January 16, 2025]; Available from: https://www.bls.gov/oes/tables.htm.

19. CSTE, *Interim Guidance for Public Health Surveillance Programs for Incident Case Classification of COVID-19-associated Hospitalizations (Updated October 2022)*. 2022, Council of State and Territorial Epidemiologists.

20. R Core Team, *R: A Language and Environment for Statistical Computing*. 2023.

21. CWCI, *Long COVID-19 Claim Characteristics and Treatment in California Workers' Compensation (June 2025)*. 2025, California Workers' Compensation Institute (CWCI).

22. Kromydas, T., et al., *Occupational differences in the prevalence and severity of long-COVID: analysis of the Coronavirus (COVID-19) Infection Survey*. Occup Environ Med, 2023. **80**(10): p. 545-552.

23. Howard, J., M. Cloeren, and G. Vanichkachorn, *Long COVID and Occupational Medicine Practice.* J Occup Environ Med, 2024. **66**(1): p. 1-5.

24. Todorov, D. and C. Whitaker, *Surveillance of Post-COVID Conditions using the Washington State Workers' Compensation System, 2020-2022*. 2023, Washington (WA) Safety & Health Assessment & Research for Prevention (SHARP)WA State Department of Labor & Industries.

25. NYSIF, *Shining a Light on Long COVID: An Analysis of Workers' Compensation Data*. 2023, NYSIF Albany, NY.

26. Vahratian, A., et al., *Prevalence of Post-COVID-19 Condition and Activity-Limiting Post-COVID-19 Condition Among Adults.* JAMA Netw Open, 2024. **7**(12): p. e2451151.

27. Bonner, C. and S.L. Ghouralal, *Long COVID and Chronic Conditions in the US Workforce: Prevalence, Productivity Loss, and Disability.* J Occup Environ Med, 2024. **66**(3): p. e80-e86.

28. Cohen, J. and Y.V.M. Rodgers, *Long COVID Prevalence, Disability, and Accommodations: Analysis Across Demographic Groups.* J Occup Rehabil, 2024. **34**(2): p. 335-349.

29. Ford, N.D., et al., *Notes from the Field: Long COVID Prevalence Among Adults - United States, 2022.* MMWR Morb Mortal Wkly Rep, 2024. **73**(6): p. 135-136.

30. NIOSH, *National Institute for Occupational Safety and Health Employed Labor Force Query system*. 2023, National Institute for Occupational Safety and Health, Division of Safety Research.

31. Hsu, P. and D.E. Hayes-Bautista, *The epidemiology of diversity: COVID-19 case rate patterns in California.* Journal of Immigrant and Minority Health, 2021. **23**(4): p. 857-862.

32. Adjaye-Gbewonyo, D., et al., *Long COVID in Adults: United States, 2022*, in *NCHS Data Brief No. 480, September 2023*. 2023, National Center for Health Statistics (NCHS).

33. UCLA Center for Policy Research, *2023 California Health Interview Survey Preliminary COVID-19 Estimates*. 2024, UCLA

34. Wambui, D., et al., *Prevalence and Risk Factors for Long COVID among California Workers Captured by a Doctor's First Report-Based Surveillance System.* J Occup Environ Med, 2025.

35. CDPH, *California Workers' Compensation Claims Data and Analysis, 2015-2022 Report*. 2024, California Department of Public Health (CDPH), Occupational Health Branch: Richmond, California. 1-19.

36. Contreras, Z., et al., *Industry Sectors Highly Affected by Worksite Outbreaks of Coronavirus Disease, Los Angeles County, California, USA, March 19-September 30, 2020.* Emerg Infect Dis, 2021. **27**(7): p. 1769-1775.

37. Anderson, N.J., C.K. Smith, and M.P. Foley, *Work-related injury burden, workers' compensation claim filing, and barriers: Results from a statewide survey of janitors.* Am J Ind Med, 2022. **65**(3): p. 173-195.

38. Schofield, K., et al., *Realities of Workers' Compensation Coverage for Agricultural Workers: Before, during, and into the Future of the COVID-19 Pandemic.* J Agromedicine, 2023. **28**(1): p. 69-72.

39. Mongeau, S., et al., *Union, employer and compensation system gaps and failures: Workers with injuries perceptions.* Work, 2021. **69**(2): p. 485-495.

40. Wuellner, S. and D. Bonauto, *Sociodemographic, Industry and Health Factors Associated With Underutilization of Workers' Compensation Insurance.* Am J Ind Med, 2026. **69**(1): p. 3-13.

41. Stave, G.M., I. Nabeel, and Q. Durand-Moreau, *Long COVID-ACOEM Guidance Statement.* J Occup Environ Med, 2024. **66**(4): p. 349-357.

42. Ottiger, M., et al., *Work ability and return-to-work of patients with post-COVID-19: a systematic review and meta-analysis.* BMC Public Health, 2024. **24**(1): p. 1811.

43. Gallegos, M., et al., *The impact of long Covid on people's capacity to work.* Ann Work Expo Health, 2023. **67**(7): p. 801-804.

44. Babalola, T.K., et al., *SARS-COV-2 re-infection and incidence of post-acute sequelae of COVID-19 (PASC) among essential workers in New York: a retrospective cohort study.* The Lancet Regional Health–Americas, 2025. **42**.

45. Pfaff, E.R., et al., *Coding long COVID: characterizing a new disease through an ICD-10 lens.* BMC Med, 2023. **21**(1): p. 58.

46. Pry, J.M., et al., *Defining long COVID using a population-based SARS-CoV-2 survey in California.* Vaccine, 2024. **42**(26): p. 126358.

47. Kyung, M., et al., *Underreporting of workers' injuries or illnesses and contributing factors: a systematic review.* BMC Public Health, 2023. **23**(1): p. 558.

48. Lunt, J., et al., *What workers can tell us about post-COVID workability.* Occup Med (Lond), 2024. **74**(1): p. 15-23.

Figure Legends

Figure 1. Data Flow for Post-Acute COVID Among California Workers' Compensation Claims 2020-2022 Legend: Specific exclusion diagnostic codes for traumatic injuries provided in Appendix. WC = Workers' Compensation, U.S. Census Bureau's Current Population Survey Annual Social and Economic Supplements 2020-2022 and Bureau of Labor Statistics Occupational Employment and Wage Statistics 2020-2022

Figure 2. Race/Ethnicity of Post-Acute COVID Claimants by Occupation Major Group, California Workers' Compensation 2020-2022 (N=8,540)

Legend: Post-acute COVID (PASC) California WC case defined as having long COVID-related diagnoses anywhere medical billing data, principal or admitting diagnosis codes, or days from injury to last bill date of more than 28 days (4 weeks); AI/AN = American Indian/Alaska Native, NH/PI= Native Hawaiian/Pacific Islander.

Figure 3. Post-Acute COVID Odds Ratios for Occupational Major Groups of California Workers Compensation Claimants, 2020-2022 (N=138,093)

Legend: Post-acute COVID (PASC) California WC case defined as having long COVID-related diagnoses anywhere medical billing data, principal or admitting diagnosis codes, or days from injury to last bill date of more than 28 days (4 weeks) and all other COVID-related and acute COVID were the comparison group. This analysis includes only records with complete information on all variables. Full model includes sex, age group, race/ethnicity, tenure, union representation, health insurance, income, large clusters of COVID (claims involving 21 or more),occupational major group, and rural-urban micropolitan/rural; Rural-urban based on injury zip code; Union representative and health insurance from US Census Bureau's Current Population Survey Annual Social and Economic Supplements 2020-2022 and income from the

Bureau of Labor Statistics Occupational Employment and Wage Statistics 2020-2022; Occupational major group reference includes: Arts, Design, Entertainment, Sports, and Media; Architecture and Engineering; Business and Financial Operations; Computer and Math; Life, Physical and Social Science.

Table 1. Demographics of California Workers Compensation Claimants, 2020-2022

(N=293,290)

	Overall (N=293,290)	Post-Acute COVID (N=14,804)	Acute COVID (N=191,571)	All other COVID-related (N=86,915)
Age Group (yrs)				
0-29	74,888 (25.5%)	1,660 (11.2%)	47,477 (24.8%)	25,751 (29.6%)
30-49	147,748 (50.4%)	8,114 (54.8%)	98,162 (51.2%)	41,472 (47.7%)
50-69	68,283 (23.3%)	4,917 (33.2%)	44,671 (23.3%)	18,695 (21.5%)
70+	2,371 (0.8%)	113 (0.8%)	1,261 (0.7%)	997 (1.1%)
Sex				
Females	135,136 (46.1%)	7,779 (52.5%)	88,971 (46.4%)	38,386 (44.2%)
Race/Ethnicity				
Latino	86,968 (29.7%)	4,430 (29.9%)	66,655 (34.8%)	15,883 (18.3%)
NL, AI/AN	678 (0.2%)	47 (0.3%)	490 (0.3%)	141 (0.2%)
NL, Asian	16,010 (5.5%)	1,067 (7.2%)	11,982 (6.3%)	2,961 (3.4%)
NL, Black	9,019 (3.1%)	618 (4.2%)	6,665 (3.5%)	1,736 (2.0%)
NL, Multiple Races	1778 (0.6%)	147 (1.0%)	1,456 (0.8%)	175 (0.2%)
NL, Native Hawaiian/PI	1564 (0.5%)	136 (0.9%)	1,182 (0.6%)	246 (0.3%)
NL, Other	9,015 (3.1%)	489 (3.3%)	6,383 (3.3%)	2,143 (2.5%)
NL, White	44,248 (15.1%)	2,600 (17.6%)	31,968 (16.7%)	9,680 (11.1%)
Self-Insured				
Yes	149,669 (51.0%)	10,458 (70.6%)	102,806 (53.7%)	36,405 (41.9%)
Tenure (yrs)				
0-9	199,289 (67.9%)	8,287 (55.9.0%)	129,669 (67.7%)	61,333 (70.6%)
10-19	53,006 (18.1%)	3,877 (26.2%)	35,946 (18.8%)	13,183 (15.2%)
20+	31,191 (10.6%)	2,365 (16.0%)	20,521 (10.7%)	8,305 (9.6%)
Region				
Bay Area	52,646 (18.0%)	1,764 (11.9%)	33,084 (17.3%)	17,798 (20.5%)
Greater Sacramento	21,052 (7.2%)	947 (6.4%)	13,473 (7.0%)	6,632 (7.6%)
Northern California	3,623 (1.2%)	187 (1.3%)	2,152 (1.1%)	1,284 (1.5%)
San Joaquin Valley	39,482 (13.5%)	2,705 (18.3%)	26,322 (13.7%)	10,455 (12.0%)
Southern California	165,494 (56.4%)	8,593 (58.0%)	109,959 (57.4%)	46,942 (54.0%)
Urbanicity				
Metropolitan	270,731 (92.3%)	13,509 (91.3%)	176,829 (92.3%)	80,393 (92.5%)
Micropolitan/Rural	19,989 (6.8%)	1,244 (8.4%)	13,292 (6.9%)	5,453 (6.3%)
Union Representation				
Higher than national average	142,855 (48.7%)	9,059 (61.2%)	96,031 (50.1%)	37,765 (43.5%)
Health Insurance Coverage				
Higher than national average	152,164 (51.9%)	9,917 (67.0%)	101,478 (53.0%)	40,769 (46.9%)
Mean Income	$73,163.8	$81,660.7	$72,935.2	$72,139.2

Footnotes: Post-acute COVID (PASC) California WC case defined as having long COVID-related diagnoses anywhere medical billing data, principal or admitting diagnosis codes, or days from injury to last bill date of more than 28 days (4 weeks) ; For race/ethnicity, counts do not add to 100%. Non-Latino (NL), American Indian/Alaska Native (AI/AN), Native Hawaiian/Pacific Islander (Native Hawaiian/PI), Other. Rural-urban based on injury zip code; Union representative and health insurance from US Census Bureau's Current Population Survey Annual Social and Economic Supplements 2020-2022 and income from the Bureau of Labor Statistics Occupational Employment and Wage Statistics 2020-2022.

Table 2. Distribution of California Workers Compensation Claimants by Major Occupational Group, 2020-2022 (N=293,290)

	Overall (N=293,290)	Post-Acute COVID (PASC) (N=14,804)	Acute COVID (N=191,571)	All other COVID-Related (N=86,915)
Major Occupational Group				
Architecture and Engineering	1,962 (0.7%)	87 (0.6%)	1,135 (0.6%)	740 (0.9%)
Arts, Design, Entertainment, Sports, and Media	871 (0.3%)	21 (0.1%)	476 (0.2%)	374 (0.4%)
Building and Grounds Cleaning and Maintenance	8,845 (3.0%)	368 (2.5%)	5,986 (3.1%)	2,491 (2.9%)
Business and Financial Operations	4,536 (1.5%)	177 (1.2%)	2,697 (1.4%)	1,662 (1.9%)
Community and Social Service	5,505 (1.9%)	290 (2.0%)	3,683 (1.9%)	1,532 (1.8%)
Computer and Math	1,146 (0.4%)	35 (0.2%)	654 (0.3%)	457 (0.5%)
Construction and Extraction	5,291 (1.8%)	177 (1.2%)	3,299 (1.7%)	1,815 (2.1%)
Education, Training, and Library	3,419 (1.2%)	205 (1.4%)	2,197 (1.1%)	1,017 (1.2%)
Farming, Fishing, and Forestry	2,233(0.7%)	73 (0.5%)	1,462 (0.7%)	698 (0.8%)
Food Preparation and Serving Related	12,713 (4.3%)	220 (1.5%)	6,844 (3.6%)	5,649 (6.5%)
Healthcare Practitioners and Technical	40,323 (13.7%)	3,869 (26.1%)	27,471 (14.3%)	8,983 (10.3%)
Healthcare Support	21,956 (7.5%)	1,303 (8.8%)	15,582 (8.1%)	5,071 (5.8%)
Installation, Maintenance, and Repair	5,760(2.0%)	160 (1.1%)	3,567 (1.9%)	2,033 (2.3%)
Legal	1,005 (0.3%)	39 (0.3%)	707 (0.4%)	259 (0.3%)
Life, Physical, and Social Science	1,723 (0.6%)	67 (0.4%)	997 (0.5%)	659 (0.8%)
Management	12,978 (4.4%)	504 (3.4%)	7,832 (4.1%)	4,642 (5.4%)
Material Moving	13,280 (4.5%)	277 (1.9%)	8,725 (4.5%)	4,278 (4.9%)
Office and Administrative Support	25,495 (8.7%)	1,059 (7.2%)	16,922 (8.9%)	7,514 (8.7%)
Personal Care and Service	2,532 (0.9%)	90 (0.6%)	1,608 (0.9%)	834 (1.0%)
Production	9,950 (3.4%)	316 (2.1%)	6,348 (3.3%)	3,286 (3.8%)
Protective Service	53,437 (18.2%)	3,568 (24.1%)	36,854 (19.2%)	13,015 (15.0%)
Sales and Related	11,996 (4.1%)	187 (1.3%)	7,515 (3.9%)	4,294 (4.9%)
Transportation	5,499 (1.9%)	180 (1.2%)	3,616 (1.9%)	1,703 (2.0%)

Table 3. Post-Acute COVID Odds Ratios by Demographic & Socioeconomic Factors, California Workers' Compensation 2020-2022 (N = 138,093)

	Post-Acute COVID (PASC)	Acute or Other all COVID-Related	Bivariate		Full Model: Direct Effect		Mixed Level with Major Occupational Group as Random Effect	
Variables	**N (%)**	**N (%)**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Female	4,500 (54.0%)	61,711 (47.6%)	1.29	1.25, 1.33	1.18	1.12, 1.25	1.19	1.12, 1.25
Age (yrs)								
0-29	876 (10.5%)	32,926 (25.4%)	0.39	0.37, 0.41	0.49	0.45, 0.53	0.49	0.45, 0.53
50-69	2,767 (33.2%)	29,016 (22.4%)	1.34	1.29, 1.39	1.46	1.38, 1.54	1.46	1.38, 1.54
70+	52 (0.6%)	745 (0.6%)	0.86	0.71, 1.04	1.19	0.88, 1.56	1.19	0.89, 1.58
Race/Ethnicity								
Latino	3,823 (45.9%)	66,273 (51.1%)	0.86	0.82, 0.90	1.19	1.12, 1.25	1.18	1.12, 1.25
NL American Indian/Alaska Native	44 (0.5%)	533 (0.4%)	1.19	0.87, 1.59	1.39	0.93, 1.89	1.39	1.02, 1.91
NL Asian	943 (11.3%)	12,360 (9.5%)	1.14	1.06, 1.23	1.01	0.93, 1.09	1.01	0.93, 1.10
NL Black	541 (6.4%)	6,618 (5.1%)	1.18	1.08, 1.29	1.27	1.15, 1.40	1.27	1.15, 1.40
NL Multiple Races	126 (1.5%)	1,310 (1.0%)	1.44	1.21, 1.71	1.46	1.20, 1.76	1.46	1.21, 1.77
NL Native Hawaiian/PI	123 (1.5%)	1,170 (0.9%)	1.53	1.27, 1.82	1.45	1.19, 1.75	1.45	1.20, 1.76
Other	421 (5.1%)	6,942 (5.3%)	0.92	0.83, 1.01	1.01	0.90, 1.12	1.01	0.91, 1.13
Tenure (yrs)								
0-4	3,212 (38.6%)	67,143 (51.7%)	--	--	--	--	--	--
5-9	1,495 (18.0%)	23,634 (18.2%)	1.38	1.31, 1.44	1.05	0.98, 1.12	1.05	0.98, 1.12
10-14	1,196 (14.4%)	12,931 (10.0%)	2.01	1.91, 2.12	1.33	1.24, 1.43	1.33	1.24, 1.43
15-19	1,079 (13.0%)	11,964 (9.2%)	1.96	1.86, 2.07	1.30	1.20, 1.40	1.30	1.20, 1.40
20+	1,346 (16.2%)	14,093 (10.9%)	2.07	1.97, 2.17	1.30	1.21, 1.40	1.30	1.20, 1.40
Union Representation	5,626 (67.6%)	73,190 (56.4%)	1.69	1.63, 1.76	0.86	0.39, 1.66	1.11	0.84, 1.47
Health Insurance	6,214 (74.6%)	77,227 (59.5%)	2.01	1.94, 2.10	0.97	0.40, 3.21	1.77	1.30, 2.40
Income			1.05	1.05, 1.06	0.98	0.98, 0.99	0.98	0.98, 0.99
'Large Clusters' -Claims 21 or more	1,670 (20.1%)	24,622 (19.0%)	1.13	1.09, 1.34	0.85	0.80, 0.90	0.85	0.81, 0.90

Micropolitan/Rural worksites	710 (8.5%)	9,522 (7.3%)	1.26	1.19, 1.34	1.14	1.05, 1.23	1.14	1.05, 1.23

Footnotes: Post-acute COVID (PASC) California WC case defined as having long COVID-related diagnoses anywhere medical billing data, principal or admitting diagnosis codes, or days from injury to last bill date of more than 28 days (4 weeks). For race/ethnicity, non-Latino (NL), American Indian/Alaska Native (AI/AN), Native Hawaiian/Pacific Islander (Native Hawaiian/PI), Other. This table includes only records with complete information on all variables. Full model includes sex, age group, race/ethnicity, tenure, union representation, health insurance, income, large clusters of COVID (claims involving 21 or more), occupational group and rural-urban micropolitan/rural; Rural-urban based on injury zip code; Union representative and health insurance from US Census Bureau's Current Population Survey Annual Social and Economic Supplements 2020-2022 and income from the Bureau of Labor Statistics Occupational Employment and Wage Statistics 2020-2022; Occupational major group reference includes: Arts, Design, Entertainment, Sports, and Media; Architecture and Engineering; Business and Financial Operations; Computer and Math; Life, Physical and Social Science. The mixed model includes sex, age group, race/ethnicity, tenure, union representation, health insurance, income, large clusters of COVID (claims involving 21 or more) and rural-urban micropolitan/rural with occupation group as a random effect.

Figure 1

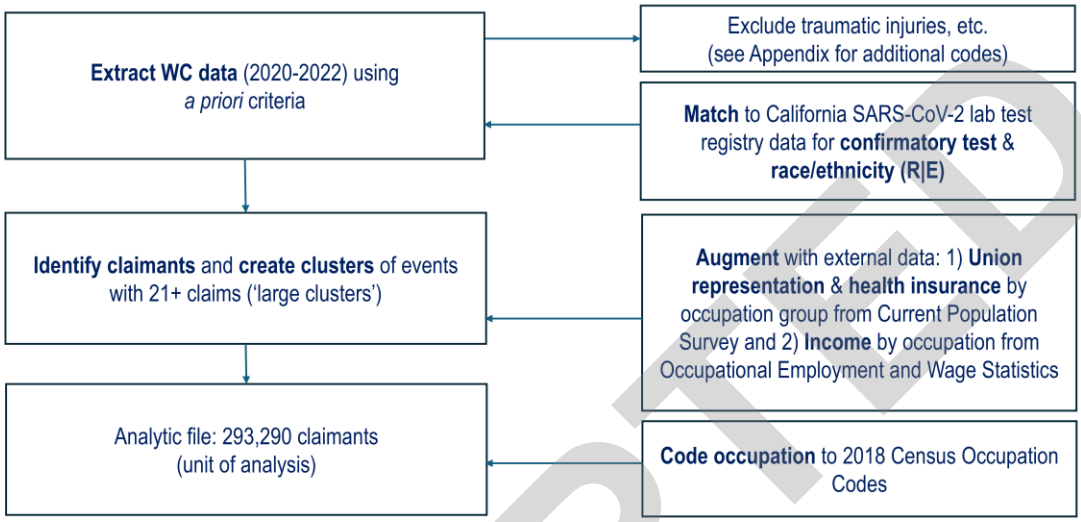


Figure 2

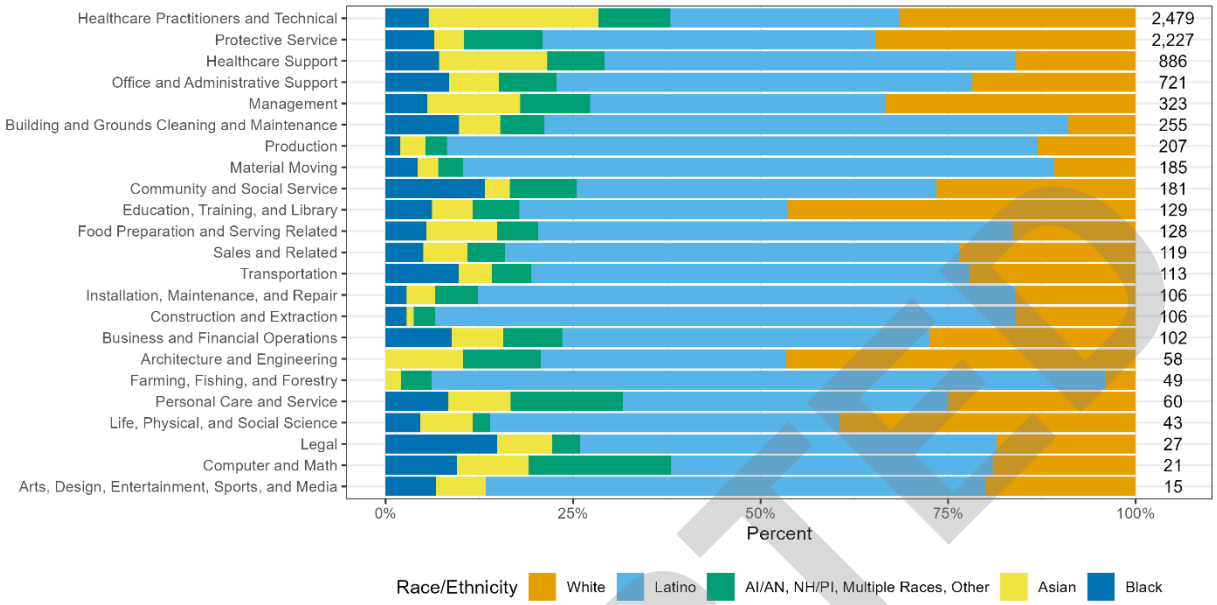
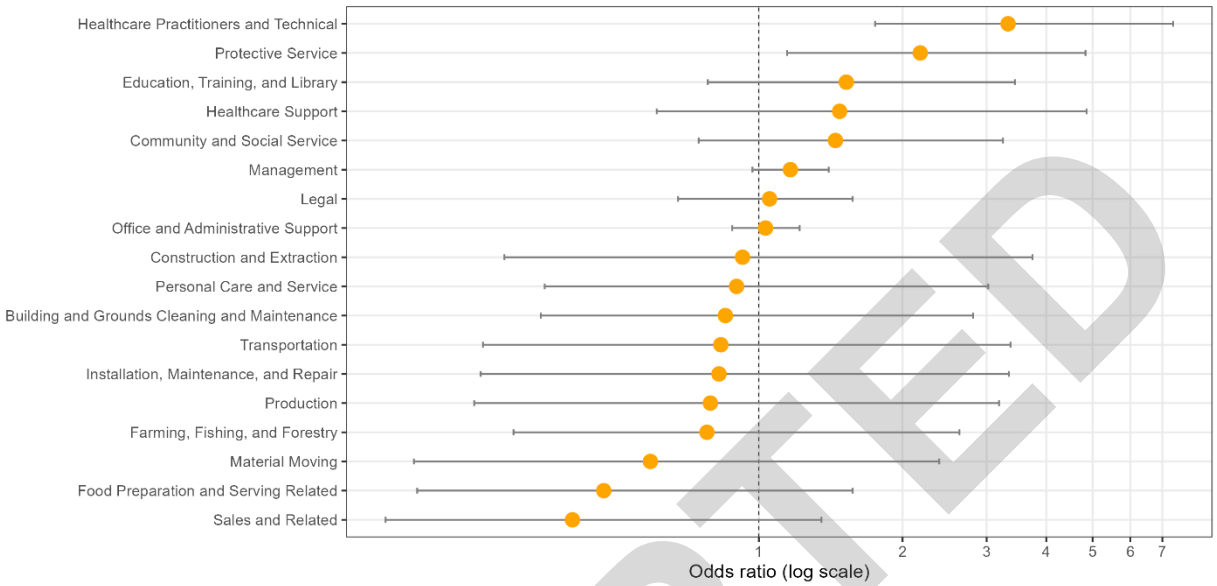


Figure 3



Graphical abstract