Measuring work-related risk of COVID-19: comparison of COVID-19 incidence by occupation and industry – Wisconsin, September 2020-May 2021

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Running Title: Risk of COVID-19 by industry and occupation in Wisconsin

Abstract

Background: Work-related exposures play an important role in SARS-CoV-2 transmission, yet few studies have measured the risk of COVID-19 across occupations and industries.

*Methods:*During September 2020 – May 2021, the Wisconsin Department of Health Services collected occupation and industry data as part of routine COVID-19 case investigations. Adults aged 18-64 years with confirmed or probable COVID-19 in Wisconsin were assigned standardized occupation and industry codes. Cumulative incidence rates were weighted for non-response and calculated using full-time equivalent (FTE) workforce denominators from the 2020 American Community Survey.

Results: An estimated 11.6% of workers (347,013 of 2.98 million) in Wisconsin, ages 18-64 years, had COVID-19 from September 2020 to May 2021. The highest incidence by occupation (per 100 full-time equivalents) occurred among personal care and services workers (22.4), healthcare practitioners and support staff (20.7), and protective services workers (20.7). High risk sub-groups included nursing assistants and personal care aides (28.8), childcare workers (25.8), food and beverage service workers (25.3), personal appearance workers (24.4), and law enforcement workers (24.1). By industry, incidence was highest in healthcare (18.6); the highest risk sub-sectors were nursing care facilities (30.5) and warehousing (28.5).

Conclusions: This analysis represents one of the most complete examinations to date of COVID-19 incidence by occupation and industry. Our approach demonstrates the value of standardized occupational data collection by public health, and may be a model for improved occupational surveillance elsewhere. Workers at higher risk of SARS-CoV-2 exposure may benefit from targeted workplace COVID-19 vaccination and mitigation efforts.

Keywords: COVID-19; Occupation; Industry; Wisconsin; Epidemiology

Introduction

Work-related exposures play an important role in SARS-CoV-2 transmission [1, 2]. Occupations requiring close contact with customers and co-workers have been linked to workforce shortages [3], severe disease [4] and death [5] among workers due to COVID-19. . While many epidemiologic studies on occupational COVID-19 risk have focused on healthcare workers [6-12], the risks of COVID-19 are present in a wide variety of work settings [2]. This has been demonstrated by outbreaks at manufacturing and food processing facilities [13, 14], correctional facilities [15], and other high-density work settings [16-18] throughout the pandemic.

Despite the importance of occupation in determining one's risk of SARS-CoV-2 exposure, relatively few studies have compared COVID-19 risk across occupation and industries in the United States. Prior studies have compared hospitalizations or deaths by occupation [4, 5, 19], or the frequency of outbreaks by industry [20, 21], but have not been able to assess individual exposure risk across different work settings. This gap is due, in part, to a lack of standardization in the collection and reporting of occupational data among U.S. public health systems. Poor occupational data for COVID-19 has not only led to delays in identification and response to workplace outbreaks, but has limited our ability to identify occupations and industries that are at high-risk for SARS-CoV-2 transmission and target these workers with public health resources and policy considerations [22]. To address this gap, in June 2020, CDC recommended that U.S. public health jurisdictions begin collecting detailed occupation and industry information for all COVID-19 cases in a standardized format to facilitate occupational coding and surveillance [22]. This approach was implemented by the Wisconsin Department of Health Services (WDHS) in September 2020.

This report utilizes the first eight months of Wisconsin's standardized occupational data collection (September 2020-May 2021) to calculate COVID-19 incidence by occupation and industry. Our observation period coincides with the first major COVID-19 surge in Wisconsin, prior to widespread COVID-19 vaccination, and after Wisconsin's "Safer At Home" order had expired (May 2020), which brought many workers back to in-person jobs. As one of the first U.S. jurisdictions to employ standardized occupational data collection for COVID-19, we demonstrate the potential value of this approach for occupational surveillance of COVID-19 and other diseases.

Methods

Data Source

Occupation and industry data were collected during routine COVID-19 case investigation interviews in Wisconsin. On September 16, 2020, free-text data fields for "Current Occupation" and "Current Industry" were added to the standard COVID-19 case interview form. Wisconsin residents, ages 18-64 years, who were reported to public health with confirmed or probable COVID-19 [23] during September 16, 2020 to May 17, 2021 were eligible for this study.

Of 418,935 cases meeting eligibility criteria, 375,930 (90%) were confirmed and 43,005 (10%) were probable COVID-19 cases. Interviews were completed for 294,057 (70%)cases, and free-text data were collected for 169,899 (41%) cases by occupation and 107,517 (27%) cases by industry. These data were supplemented with industry and occupation data obtained during registration at state-run COVID-19 testing sites, specific occupational risk questions on the COVID-19 case interview form, and matching employer names to the Wisconsin unemployment insurance database (Fig 1). These supplemental data sources contributed an additional 66,597 (16%) and 98,324 (23%) data entries for occupation and industry, respectively.

Industry and Occupation Coding

The NIOSH Industry and Occupation Coding System (NIOCCS) [24] was used to generate standardized occupation and industry codes. At least one input (occupation and/or industry) was available for 260,101 cases (62% of eligible cases), which were entered into the NIOCCS auto-coding system. Outputs codes with NIOCCS-generated confidence scores ≥ 0.5 (maximum = 1) were accepted (194,017; 75% of coded cases), and the remainder were reviewed manually for accuracy, and re-coded if necessary. Our final analytical sample contained 251,212 cases (60% of eligible cases). Fifty-three percent (n=223,262) of cases were assigned 2018 Standard Occupational

Classification (SOC) codes and 57% (n=238,607) were assigned 2017 North American Industry Classification System (NAICS) codes [25].

Incidence Estimation and Non-Response Adjustment

Wisconsin workforce data for incidence estimation were available from the experimental 2020 American Community Survey (ACS) [26-28]. Workforce size was adjusted for full-time equivalent (FTE) employment and included persons aged 18-64 years who were employed in Wisconsin in 2020.

The cumulative incidence of COVID-19 (cases per 100 FTE) was estimated for each major and minor SOC and NAICS category, as well as by age, sex, race, ethnicity, and broad SOC group. Crude incidence rates were adjusted for non-response to account for non-participation or low-quality responses among eligible cases. Response weights were calculated using logistic regression, with response as an outcome and age, sex, race, local health jurisdiction, and illness onset (or specimen collection) month as statistically significant predictors of response ($p < 0.05$) (Appendix 1, Table S1). Weights were assigned to cases with known industry and occupation codes based on the inverse probability of response from the regression equation and were applied to all incidence rates in this report. Standard errors and 95% confidence intervals for weighted incidence rates and corresponding risk ratios were calculated by combining the respective errors from weighted case totals (numerator) and 2020 ACS workforce estimates (denominator). P-values for risk ratios were assessed at the $\alpha = 0.05$ level.

Incidence rates and risk ratios were not estimated for groups excluded from ACS workforce data (e.g., persons reporting non-paid work or unemployment, institutionalized persons, and persons in the armed forces). We also excluded occupation and industry categories for which final incidence rates produced relative standard errors (RSE) > 0.3 [29] (Appendix 1, Text S2). All statistical analyses were carried out using R v 4.1 and Stata v16.0 . This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy[1].

[1] See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

Results

Characteristics of workforce with COVID-19

During September 2020 – May 2021, 11.6% of employed persons in Wisconsin (347,013 of 2.98 million), aged 18-64 years, were diagnosed with COVID-19. This produced a final FTE-adjusted cumulative incidence of 12.3 per 100 FTE (95% confidence interval (CI): 12.1-12.5) (Table 1). Incidence was higher in females (14.6 per 100 FTE) compared to males (11.1 per 100 FTE) and was highest in younger age groups (18.2 vs. 10.8 per 100 FTE among adults aged 18-24 and 55-64, respectively). Compared to White workers (12.1 per 100 FTE), Black or African American workers (14.2 per 100 FTE) had significantly increased incidence, while incidence among American Indian/Alaska Native (17.3 per 100 FTE) workers was elevated, but not statistically significant. Asian (11.0 per 100 FTE) workers had the lowest incidence among all race categories. Hispanic workers (16.4 per 100 FTE) had a risk of COVID-19 that was 1.52 times that of non-Hispanic workers (10.8 per 100 FTE).

Incidence among major occupational groups

The highest cumulative incidence occurred among workers in Personal Care and Service occupations (SOC 39), a major occupational group that includes childcare workers, hairdressers, and other personal services jobs. This group experienced 22.1 cases per 100 FTE workers, representing a 79% higher risk (relative risk (RR) = 1.79) compared to the average incidence across all occupations (Fig 2). Other major occupational groups with significantly elevated risk included Healthcare Practitioners and Support (SOC 29-31) (20.7 per 100 FTE; RR = 1.68), Protective Services (SOC 33) (20.7 per 100 FTE; RR = 1.68), Food Preparation and Serving (SOC 35) (19.7 per 100 FTE; RR = 1.68), Building and Maintenance (SOC 37) (15.6 per 100 FTE; RR = 1.26) and Education Instruction and Library (SOC 25) (14.4 per 100 FTE; RR = 1.16).

Incidence among minor and broad occupational groups (sub-groups)

Home Health Aides, Personal Care Aides, and Nursing Assistants (SOC 31-1100) had the highest cumulative incidence among minor occupational groups (28.8 per 100 FTE) (Appendix 1, Figure S3), with high rates among both nursing assistants (32.4), and home health or personal care aides (24.8). The second highest minor occupational group (25.8 per 100 FTE) was Other Personal Care and Service workers (SOC 39-9000), which included childcare workers (29.5) and recreation and fitness workers (17.4). Food and Beverage Serving workers (SOC 35-3000) ranked third (25.3 per 100 FTE), with particularly high rates among waiters (21.8), fast food workers (25.5), and bartenders (37.0), the broad occupation with the highest incidence among those analyzed. Personal Appearance workers (SOC 39-5000) (barbers, hairstylists, manicurists, etc.) ranked fourth with an incidence of 24.4 per 100 FTE. Law enforcement workers (SOC 33-3000), the occupation with the highest crude incidence among workers (26.1 per 100 workers), had the fifth highest incidence after adjusting for FTE (24.1 per 100 FTE). This group includes police officers (22.6) and correctional officers (33.9), the broad occupation with the second highest incidence among those analyzed. Retail Sales workers (SOC 41-2000) and K-12 Teachers (SOC 25-2000) ranked sixth and tenth in incidence with rates of 21.3 and 19.0 per 100 FTE, respectively. See Appendices 2 (data supplement) for complete results by occupation .

Incidence among major industry sectors

The highest cumulative incidence and greatest number of COVID-19 cases occurred in the Healthcare industry (NAICS 62; n = 71,531), with an incidence of 18.6 per 100 FTE (Fig 3). The Accommodation and Food Services industry (NAICS 72) (17.4; RR = 1.40), Public Administration (NAICS 92) (14.4; RR = 1.15), Other Services (NAICS 81) (14.2; RR = 1.14), Retail Trade (NAICS 44-45) (13.4; RR = 1.08) and Educational Service (NAICS 61) (13.4; RR = 1.08) industries all had significantly elevated risk compared to all other industries combined.

Incidence among industry sub-sectors

Nursing and residential care facilities had the highest incidence (30.5 per 100 FTE) among all industry sub-sectors included in this analysis (Appendix 1, Figure S4). Warehousing and storage facilities (NAICS 493) ranked second among industry sub-sectors with an incidence of 28.5 per 100 FTE. Private households (NAICS 814), a sub-sector that includes private caregivers, house cleaners, nannies, and other domestic workers, ranked third (26.4 per 100 FTE). Other high incidence industry sub-sectors included transportation support activities (NAICS 488) (26.4 per 100

FTE), gasoline stations (NAICS 447) (21.8 per 100 FTE), justice and public safety (NAICS 922) (19.2 per 100 FTE), personal and laundry services (NAICS 812) (19.1 per 100 FTE), and food services and drinking places (NAICS 722) (18.3 per 100 FTE). See Appendix 2 (data supplement) for complete results by industry.

Discussion

We estimated the incidence of COVID-19 by occupation and industry in Wisconsin during September 2020 – May 2021. Overall, 11.6% of Wisconsin workers had confirmed or probable COVID-19 during the observation period (12.3 per 100 FTE), representing a high risk of COVID-19 to workers during this time.

Personal Care and Service occupations, a group that includes childcare workers, hairdressers, and other services jobs, experienced the highest incidence of COVID-19 (22.1 per 100 FTE) in our analysis. These jobs often require close contact with clients and may involve exposure to SARS-CoV-2 without the same level of institutional controls available in healthcare settings. High incidence among personal appearance workers (hair stylists, manicurists, etc.) was consistent with their high-risk designation (close proximity, indoor, public-facing) in the SARS-CoV-2 Occupational Exposure Matrix (SOEM) [30], as well as studies showing poor ventilation in salon settings [31]. Childcare workers, the broad occupation with the highest incidence in this group, provided essential in-person services during this period. High incidence among these workers highlights the risks experienced in this setting where masking and social distancing might have been challenging.

Healthcare practitioners and support staff experienced the second highest incidence in our analysis (20.7 per 100 FTE). This is consistent with multiple prior studies showing high incidence in this group [6-12] . The highest risk sub-group in our analysis were support staff comprising of nursing assistants, home health aides, and personal care assistants. Prior studies have also found high incidence in this group [6, 32]. This sub-group is commonly employed in nursing care facilities, a sub-sector that has experienced frequent outbreaks [33], and, in our study, had the highest incidence among all industry sub-sectors. Within nursing care facilities, health care support workers were disproportionately affected, representing 38% of workers in these facilities but nearly half (48%) of all COVID-19 cases in the residential care sub-sector (others included food staff, healthcare providers, maintenance workers, and managers). Nursing assistants in nursing care facilities are also more likely to hold second jobs compared to other healthcare workers, increasing the potential for outbreaks to cross workplaces [34].

The high incidence of COVID-19 found among Protective Service occupations (20.7 per 100 FTE; 3rd highest occupational group) in Wisconsin was also observed among law enforcement and first responders in an Arizona cohort [35], and is consistent with their designation in SOEM as high-risk due to frequent close contact with the public [30]. Two other U.S. seroprevalence studies early in 2020, however, did not find elevated risk in this group [6, 36]. The longer timespan of our study, which occurred prior to widespread vaccination and during a period of substantial transmission in Wisconsin may account for this difference. The fact that Wisconsin correctional facilities experienced several large COVID-19 outbreaks in fall 2020 [15] likely contributed to high incidence in this group, and to correctional officers having the second highest incidence among all broad occupations in Wisconsin.

Workers in Food Service and Retail Trade experienced high COVID-19 incidence during the observation period. These workers are likely to have prolonged exposure to unmasked persons, and are less likely than other occupations to have access to paid leave [37], exacerbating workplace risks for this group. Within this sub-group, bartenders experienced the highest risk (37.0 per 100 FTE), and the highest risk among all broad occupations. This is consistent with a Norwegian study that identified bartenders as the occupation with the highest incidence after pandemic lockdowns were lifted [38].

With respect to industry, high-risk sectors largely aligned with analogous high-risk occupations (i.e., healthcare, food service, public safety) discussed above. One exception was warehouse facilities, which had the second highest incidence among all industry sub-sectors. This sector experienced frequent outbreaks during 2020-2021 [20, 33], and the large number of materials handlers, transportation workers, and production workers on-site could explain observed risk estimates. Another notable industry sub-sector was food manufacturing, which had a lower incidence than expected (13.8 per 100 FTE; 16th ranked sub-sector). Outbreaks in this sector were widely reported in Wisconsin in spring 2020 [13], prior to data collection for this study. Thus, many workers had recovered from recent infections, before for the observation period, which could have led to underestimation of risk in this high-density workplace.

Strengths

There are several notable strengths of our approach. First, this work represents one of the largest and most complete examinations to date of COVID-19 risk among occupations and industries. This led to identification of high incidence rates among several previously under-recognized groups such as personal appearance workers, childcare workers, food service workers, and others. Second, our integration of NIOCCS auto-coded industry and occupation information into routine COVID-19 case interviews is novel. NIOCCS has become an important tool for analyzing occupational risk factors for a variety of diseases, but has primarily been used retrospectively [39, 40]. Our real-time data capture and coding represents a strong model for occupational surveillance that could benefit other U.S. jurisdictions. Third, our study benefitted from the opportune timing of the observation period during September 2020 to May 2021. This period was characterized by high incidence in Wisconsin, widespread availability of COVID-19 testing, and participation in case investigation interviews (75% of confirmed and probable cases were reached for interview during this period). This time period was also after the Wisconsin "Safer At Home" order was lifted in May 2020, when many workers had returned to in-person work. Emergence of variants and proliferation of at-home antigen tests later in 2021 led to declines in case reporting, follow-up, and interview completion in Wisconsin. This likely increased representativeness and reduced the impact of reporting or testing biases in our analysis.

Limitations

These findings are subject to several limitations. First, it was not possible to distinguish between exposures that occurred at the workplace versus other locations (e.g., community, household) in this analysis. Thus, risk estimates for each occupation or industry could be affected by social or behavioral risk factors unrelated the specific work setting if such factors are differentially distributed across occupations and industries. Second, 2020 ACS estimates for workforce size are considered experimental. Certain groups, particularly low-income and racial and ethnic minority groups, may be underrepresented in ways that could affect occupational estimates [41]. Third, despite efforts to supplement case interview data with other available data sources, industry and occupation inputs were missing for 43% and 47% of eligible cases for this analysis, respectively. The use of non-response weights to account for missing data, while powerful, were likely not able to account for all sector-specific differences in response probability. Lastly, our adjustment methods could not account for differences in testing behaviors between occupations and industries. Mandatory screening testing in some industries or increased availability of workplace or community testing options could have biased reported estimates.

Conclusions

In this analysis, we described COVID-19 incidence by occupation and industry in Wisconsin. Our findings highlighted the high incidence of COVID-19 in Wisconsin among workers in service occupations and the healthcare industry during September 2020 – May 2021, and identified multiple occupational sub-groups that were particularly impacted during this peak period of transmission. Groups at increased risk of workplace exposure to SARS-CoV-2 could benefit from continued efforts to promote COVID-19 vaccination, booster coverage, and other setting-specific mitigation strategies such as mask use, symptom screening, improved ventilation, and testing when indicated by local conditions.

More broadly, collection of occupational data for COVID-19 cases in many U.S. states remains limited to outbreaks, specific jobs-of-interest, or other non-standardized data formats. Wisconsin was among the first U.S. states to implement routine collection and standardization of industry and occupation information into COVID-19 case investigations. The benefits of this approach in Wisconsin included the ability to rapidly respond to high-risk work settings based on a systematic comparison of COVID-19 risk across occupations and industries. This could serve as a model for other jurisdictions.

NOTES

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Disclaimer

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Conflict of Interest

KM reports the following grants or contracts unrelated to this work: State Occupational Safety and Health Surveillance Program (U60) 5U60OH010898-07, two short-term contracts (75D30121P10334 and 75D30121P11161) from the Worker's Compensation Program at CDC, National Institute for Occupational Safety and Health, and CDC grant Wisconsin Fundamental-Plus Occupational Health Surveillance Project NU50CK000534-03-00. KMc reports a leadership or fiduciary role with Wisconsin Occupational Surveillance Advisory Group.

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Table 1 Total cases, full-time equivalent (FTE) workers, cumulative incidence, and relative risk of COVID-19 with 95% confidence intervals (CI), by demographic characteristics, occupation, and industry, among Wisconsin workers, ages 18-64 – September 2020-May 2021.

Characteristics	Confirmed and Probable Cases[¶]	Total full-time equivalent (FTE) workers, 2020	Cumulative incidence per 100 FTE (95% CI)	Relative Risk (95% CI)[†]
Age				
18-24	50,431	276,526	18.2 (17.1-19.4)	1.69 (1.56-1.82)**
25-34	82,840	646,432	12.8 (12.3-13.4)	1.18 (1.11-1.26)**
35-44	76,560	653,088	11.7 (11.2-12.2)	1.08 (1.02-1.15)**
45-54	75,567	635,214	11.9 (11.4-12.4)	1.10 (1.04-1.17)**
55-64	61,615	569,400	10.8 (10.4-11.3)	Ref.
Sex				
Female	179,098	1,222,570	14.6 (14.3-15.0)	1.32 (1.27-1.37)**
Male	167,465	1,512,184	11.1 (10.8-11.4)	Ref.
Race[‡]				
Black or African American	19,314	135,710	14.2 (12.6-15.9)	1.17 (1.04-1.32)**
Asian	8,285	75,000	11.0 (9.5-12.6)	0.91 (0.79-1.05)
American Indian/Alaska Native	3,661	21,135	17.3 (10.3-24.4)	1.43 (0.95-2.14)
White	284,932	2,345,474	12.1 (12.0-12.3)	Ref.
Ethnicity				
Hispanic	31,009	189,183	16.4 (14.9-17.9)	1.52 (1.38-1.67)**
Non-Hispanic	282,494	2,621,542	10.8 (10.6-10.9)	Ref.
Occupation (Major Groups)[§] *Listed as "SOC Code – SOC Title"*				
11 - Management	30,743	359,680	8.5 (8.1-9.0)	0.69 (0.64-0.75)**
13 - Business and Financial Operations	13,823	160,510	8.6 (7.9-9.3)	0.70 (0.61-0.78)**
15 - Computer and Mathematical	6,247	91,632	6.8 (6.1-7.5)	0.55 (0.45-0.66)**
17 - Architecture and Engineering	6,629	66,713	9.9 (8.7-11.2)	0.81 (0.68-0.93)**
19 - Life, Physical, and Social Science	2,697	32,358	8.3 (6.8-9.9)	0.68 (0.49-0.86)**
21 - Community and Social Services	5,982	41,564	14.4 (12.2-16.6)	1.17 (1.01-1.32)
23 - Legal	1,834	19,704	9.3 (7-11.6)	0.75 (0.51-1.00)*
25 - Educational Instruction and Library	22,753	158,427	14.4 (13.2-15.5)	1.16 (1.08-1.24)**
27 - Arts, Design, Entertainment, Sports, and Media	4,010	47,675	8.4 (7-9.8.0)	0.68 (0.52-0.84)**
29-31 - Healthcare Practitioners and Support Staff	54,874	264,673	20.7 (19.5-22.0)	1.68 (1.62-1.74)**
33 - Protective Service	9,149	44,220	20.7 (17.2-24.1)	1.68 (1.51-1.84)**
35 - Food Preparation and	17,310	87,899	19.7 (17.7-21.7)	1.60 (1.49-

Serving				1.70)**
37 - Building and Ground Cleaning and Maintenance	10,575	67,897	15.6 (13.8-17.4)	1.26 (1.14-1.38)**
39 - Personal Care and Service	10,074	45,626	22.1 (18.8-25.4)	1.79 (1.64-1.94)**
41 - Sales and Related	28,123	215,471	13.1 (12.1-14.0)	1.06 (0.98-1.13)
43 - Office and Administrative Support	34,714	268,574	12.9 (12.2-13.7)	1.05 (0.99-1.11)
45 - Farming, Fishing, and Forestry	1,368	27,113	5.0 (4.0-6.1)	0.41 (0.19-0.62)**
47 - Construction and Extraction	17,501	133,686	13.1 (12.0-14.2)	1.06 (0.97-1.15)
49 - Installation, Maintenance, and Repair	10,934	104,575	10.5 (9.4-11.5)	0.85 (0.75-0.95)**
51 - Production	33,553	289,990	11.6 (10.9-12.3)	0.94 (0.87-1.00)*
53 - Transportation and Material Moving	24,120	206,593	11.7 (10.9-12.5)	0.95 (0.87-1.02)
Industry (Major Sectors)[§§] *Listed as "NAICS Code – NAICS Title"*				
11 - Agriculture, Forestry, Fishing and Hunting	4,209	80,049	5.3 (4.6-5.9)	0.42 (0.30-0.54)**
21 - Mining, Quarrying, and Oil and Gas Extraction	355	4,305	8.3 (4.3-12.2)	0.66 (0.18-1.14)
22 - Utilities	3,206	22,426	14.3 (11.4-17.2)	1.15 (0.94-1.35)
23 - Construction	19,724	198,319	9.9 (9.2-10.7)	0.80 (0.72-0.87)**
31-33 - Manufacturing	63,342	546,528	11.6 (11.1-12.1)	0.93 (0.88-0.97)**
42 - Wholesale Trade	7,022	73,804	9.5 (8.4-10.6)	0.76 (0.64-0.88)**
44-45 - Retail Trade	32,906	244,733	13.4 (12.6-14.3)	1.08 (1.01-1.14)*
48-49 - Transportation and Warehousing	15,488	116,465	13.3 (12.1-14.5)	1.07 (0.97-1.16)
51 - Information	2,998	44,687	6.7 (5.6-7.8)	0.54 (0.38-0.70)**
52 - Finance and Insurance	14,294	145,129	9.8 (9-10.7)	0.79 (0.70-0.88)**
53 - Real Estate and Rental and Leasing	4,035	29,260	13.8 (11.4-16.2)	1.10 (0.93-1.28)
54 - Professional, Scientific, and Technical Services	15,058	152,898	9.8 (9.1-10.6)	0.79 (0.71-0.87)**
56 – Admin, Support, and Remediation Services	9,817	91,673	10.7 (9.4-12.0)	0.86 (0.74-0.98)*
61 - Educational Services	30,148	225,127	13.4 (12.5-14.3)	1.07 (1.01-1.14)*
62 - Health Care and Social Assistance	71,531	384,225	18.6 (17.7-19.5)	1.49 (1.44-1.54)**
71 - Arts, Entertainment, and Recreation	4,746	40,029	11.9 (9.8-13.9)	0.95 (0.77-1.13)
72 - Accommodation and Food Services	20,395	116,923	17.4 (15.8-19.0)	1.40 (1.30-1.49)**
81 - Other Services (except Public Administration)	14,500	102,340	14.2 (12.9-15.4)	1.14 (1.05-1.22)**
92 - Public Administration	15,979	111,316	14.4 (12.9-15.8)	1.15 (1.05-1.25)**

TOTAL	**347,013**	**2,811,538**	**12.3 (12.1-12.5)**	

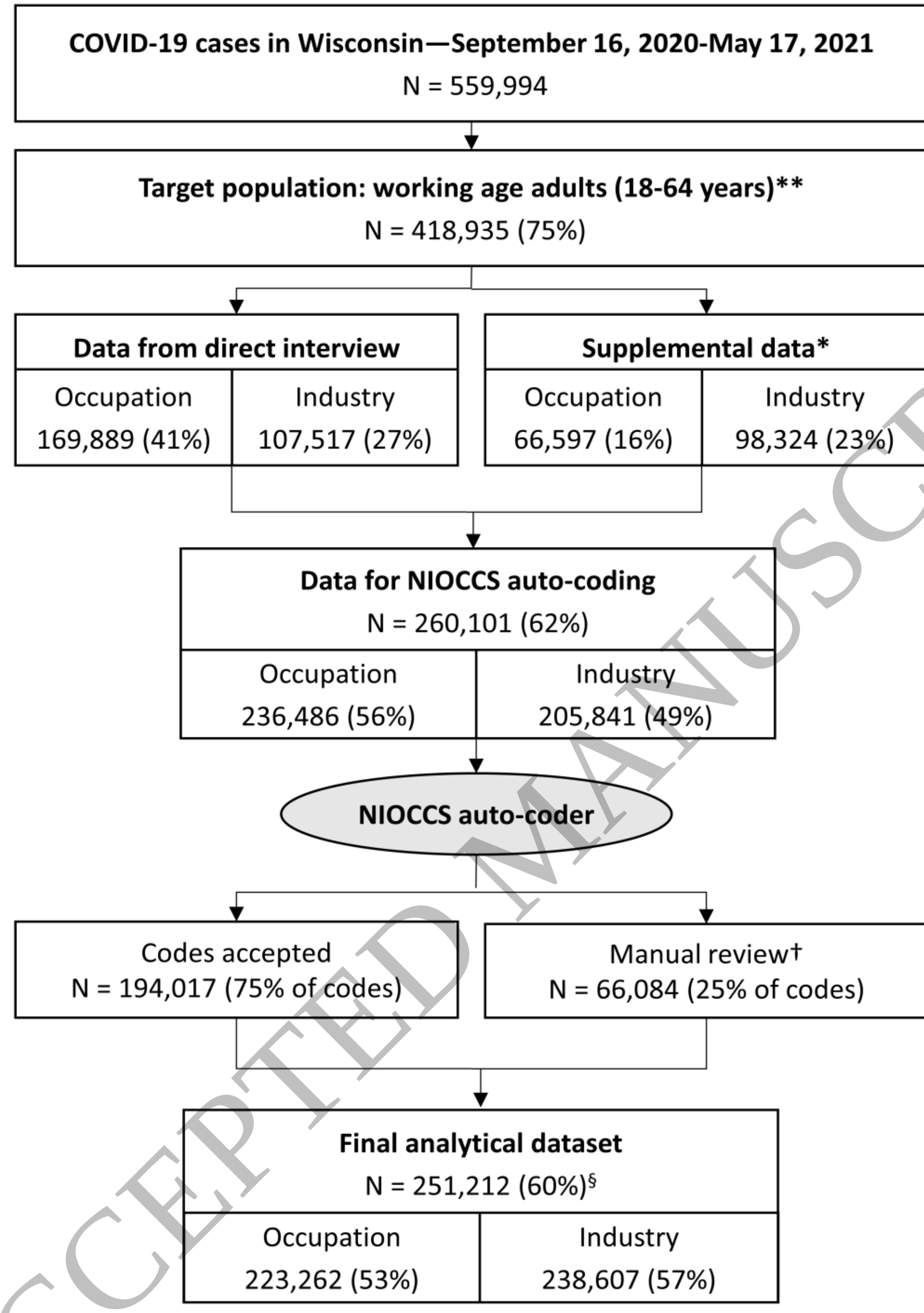
* $p<0.05$; ** $p<0.01$
[¶] The number of cases reported represents the final weighted estimates for case totals in each category after non-response adjustment, after excluding cases among all non-paid or unemployed persons (e.g., retired, student, volunteer, homemaker) and the armed forces.
[†]The reference value used for risk ratio calculations among major occupation and industry groups was the combined incidence across all groups.
[‡]Other race categories represented among cases ("Native Hawaiian or Pacific Islander", "Multiple Races", "Unknown" and "Other") were not able to be calculated due to non-concordance with race categories given in ACS denominator data.
[§]Major occupational groups based on 2018 Standard Occupational Classification (SOC) system
[§§]Major industry sectors based on the 2012 North American Industry Classification System (NAICS)

Figure Legends

Fig 1. Flow diagram for consolidation of industry and occupation data, auto-coding, validation of codes.

Fig 2. Cumulative incidence (per 100 full-time equivalent (FTE) worker) among 21 major occupations and 142 broad occupations in Wisconsin, September 2020-May 2021. Broad occupations (red dots) are shown in-line with the major occupations (black diamonds with 95% confidence intervals) to which they pertain. Labels included for selected broad occupations (see Appendix 2: Data Supplement for complete results). Occupations classified using the 2018 Standard Occupational Classification (SOC) System. Broad occupations excluded if relative standard error of the estimate > 0.3.

Fig 3. Cumulative incidence (per 100 full-time equivalent (FTE) worker) among 19 industry sectors and 80 industry sub-sectors in Wisconsin, September 2020-May 2021. Industry sub-sectors (red dots) are shown in-line with the industry sectors (black diamonds with 95% confidence intervals) to which they pertain. Labels included for selected industry sub-sectors (see Appendix 2: Data Supplement for complete results). Industry classified using the 2012 North American Industry Classification System (NAICS). Industry sector and sub-sectors excluded if relative standard error of the estimate > 0.3.



*Supplemental data included: patient registration data at COVID-19 test sites, occupational risk questions during case interviews, patient linkages to facility-based outbreak, and employer names matched to Wisconsin unemployment insurance database.

**Unless otherwise noted, all percentages listed below this represent a percent of the target population (N = 418,935)

†Manual review conducted on codes with NIOCCS confidence score < 0.5, and included assigning new codes to entries that were missing or unable to be coded by NIOCCS, or excluding entries with insufficient data

§Final dataset included 38,970 (16%) unpaid or not-employed persons, and 503 (0.2%) members of armed forces, which were not used for rate calculations

Figure 1
165x241 mm (x DPI)

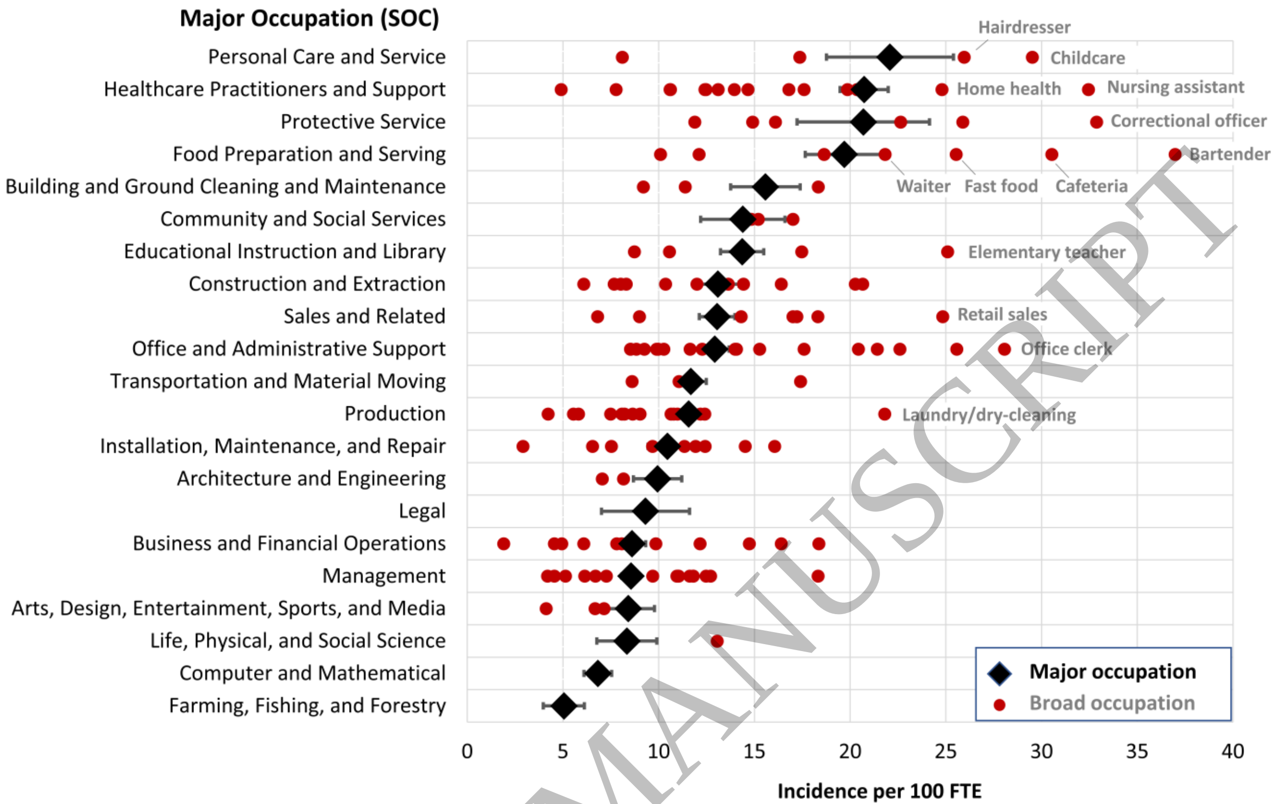


Figure 2
178x116 mm (x DPI)

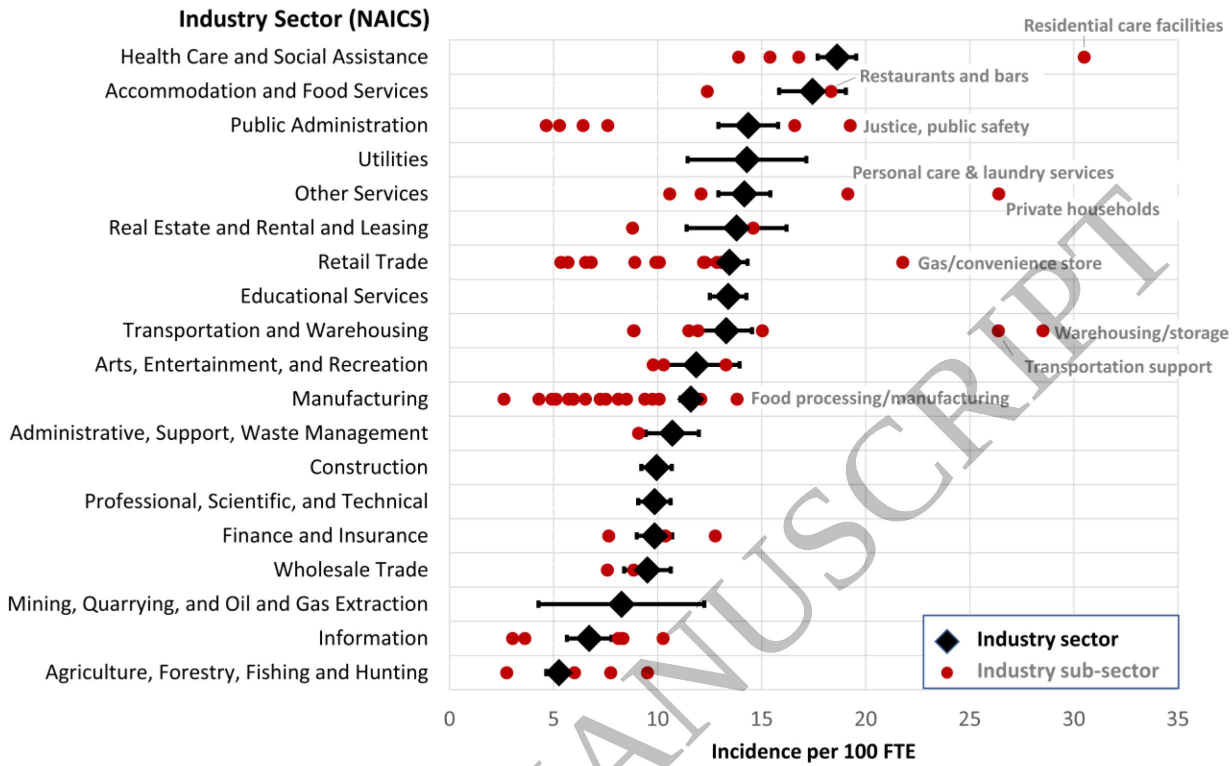


Figure 3
178x116 mm (x DPI)