Work and Life in the Balance: COVID-19 Mortality by Usual Occupation and Industry in Wisconsin

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ABSTRACT

Introduction: Work is central to the discourse surrounding the pandemic. Going to work during the COVID-19 pandemic put individuals at risk for both disease and death. This study assesses COVID-19 mortality by industry and occupation for working-age adults in Wisconsin and applies a health equity lens to understand COVID-19, demographics, work, and mortality in the state.

Methods: We used vital records data to evaluate COVID-19 mortality in Wisconsin. We assessed the demographics of working-age decedents using chi-square tests and logistic regression. We also classified decedents by usual occupation with Standard Occupational Classification (2018) and North American Industry Classification System (2017) codes to calculate mortality rates. We then calculated proportional mortality ratios to evaluate if mortality rates from COVID-19 in industry or occupation groups were significantly higher than the overall (ie, average) mortality rate from COVID-19 among all working-age Wisconsin adults.

Results: Both Asian/Pacific Islander and Hispanic individuals in Wisconsin had elevated likelihoods of dying from COVID-19. Lower levels of education also were associated with a higher likelihood of COVID-19–attributable death. Additionally, we found several occupations and industries that had elevated mortality rates from COVID-19. Proportional mortality ratios showed higher than expected mortality for several occupations including Protective Service; Office and Administrative Support; Farming, Fishing, and Forestry; and Installation, Maintenance, and Repair. Moreover, several industries had elevated proportional mortality ratios, including Agriculture, Forestry, Fishing, and Hunting; Finance and Insurance; Transportation and Warehousing; and Public Administration.

Discussion: The lessons of the pandemic are important for public health and worker safety. Understanding who bears disparate risks allows us to prepare, communicate, and mitigate risk.

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INTRODUCTION

The SARS-CoV-2 virus (COVID-19 virus) has killed at least 14 469 Wisconsin residents and continues to cause deaths within the state.[1] The COVID-19 pandemic profoundly affected many aspects of society, and work—a key social determinant of health,[2,3]—was not exempt. Rather, work – not only in terms of having or not having employment, but also with regards to the conditions and location(s) where work was being done – was often central to pandemic discourse. As the pandemic captured the national consciousness, we saw discussions about frontline workers,[4,5] working from home,[6] telemedicine,[7] and government interventions (eg, safer-at-home orders,[8] presumption for worker's compensation,[9] and mask or vaccine mandates[10,11]). This list of topics demonstrates how central work was to the unfolding pandemic. Leaving home for work during this period put workers at risk not just for disease, but for death.[12] Additionally, national findings[13] and some early Wisconsin data[5] suggested significant racial disparities in COVID-19 case counts and mortality. While findings on COVID-19 exposure and diagnoses among workers in Wisconsin have been published previously,[14] there is currently no Wisconsin-specific analysis of mortality among working-age adults or by industry and occupation. Given that exposures only tell part of the story, our analysis takes a health equity lens and explores the relationships between demographics and COVID-19 mortality among working-age Wisconsin decedents.

Moreover, these analyses focus on deaths from COVID-19 by industry and occupation for working-age adults and contribute to our understanding of the relationship between COVID-19, demographics, work, and mortality in the state.

Table 1. Demographic Characteristics of Individuals With COVID-19–Attributable Deaths vs All Other Causes of Death – Working-age Wisconsin Decedents, March 19, 2020-December 31, 2022

	COVID-19 n = 3321		Other Causes n = 36 415		χ^2	*P* value
	Count	%	Count	%		
Age (years)						
16-19	14	0.42	538	1.48	72.06	< 0.0001
20-24	16	0.48	1081	2.97		
25-34	143	4.31	3378	9.28		
35-44	343	10.33	4718	12.96		
45-54	833	25.08	7606	20.89		
55-59	806	24.27	7596	20.86		
60-64	1166	35.11	11 498	31.57		
Race						
American Indian/Alaska Native	77	2.32	794	2.18	85.94	< 0.0001
Asian/Pacific Islander	113	3.40	500	1.37		
Black	410	12.35	4993	13.71		
White	2721	81.93	30 128	82.74		
Ethnicity						
Hispanic	321	9.67	1656	4.55	169.69	< 0.0001
Non-Hispanic	2997	90.24	34 695	95.28		
Unknown	3	0.90	64	0.18		
Sex[a]						
Female	1256	37.82	13 155	36.13	3.78	0.052
Male	2065	62.18	23 259	63.87		
Education						
< High school	431	12.98	5127	14.08	13.50	0.0091
High school graduate	1601	48.21	17 588	48.30		
Some college, associate's or bachelor's degree	1138	34.27	11 840	32.51		
Advanced degree	84	2.53	1229	3.37		
Unknown/missing	67	2.02	631	1.73		

[a]Excludes "Unknown" Sex (n = 1).

METHODS

Data Sources

Analyses were conducted using Wisconsin vital records data from March 19, 2020, through December 31, 2022. This start date was chosen because it was the date that the first official COVID-19 death was reported in the state.[15] In Wisconsin, all deaths are captured by the Vital Records Office at the Wisconsin Department of Health Services. Wisconsin deaths are collected and reported by individual coroners and medical examiners at the county level.[16] The information gathered on decedents includes date of death, cause of death (including contributing causes), and sociodemographic information (eg, race, ethnicity, sex, age, education, and usual occupation). The National Institute for Occupational Safety and Health Industry and Occupation Computerized Coding System (NIOCCS) autocoder was used to convert free-text industry and occupation from vital records into Standard Occupational Classification (SOC) (2018) and North American Industry Classification System (NAICS) (2017) codes.[17] Detailed information about current SOC and NAICS codes is available via the US Bureau of Labor Statistics.[18,19] We obtained the most recent population estimates from the American Community Survey (ACS) (2017-2021)[20] via the Integrated Public Use Microdata Series platform from the University of Minnesota's Institute for Social Research and Data Innovation.[21]

Classification of Deaths Due to COVID-19

COVID-19 mortality was determined with a text search of the immediate cause of death and all contributing cause of death fields. Our definition was based on the Council of State and Territorial Epidemiologists' (CSTE) interim guidance for classification of COVID-19–associated deaths for public health surveillance.[22] However, we found that many of the key terms suggested by this guidance were too specific given the variability in the case note entries in the death records (eg, "severe acute respiratory syndrome coronavirus 2019"). As such, we chose the terms "COVID," "SARS," and "COV2" to create our definition. The term "corona" also was considered but was overly inclusive of non-COVID sources of mortality (eg, "coronary artery disease"). For validation, we compared our cases against the mass casualty indicator created by the Wisconsin Vital Records Office as an internal indicator of deaths due to COVID-19. Validation of our case detection showed that our method detected 209 cases more than the internal indicator. All of these cases were manually reviewed, and all met our classification for COVID-19–attributable death.

Sample

During the study period, 39 736 working-age decedents (ie, aged 16-64 years) were recorded in the vital records data, and 3321 of those (8.36%) had a COVID-19–attributable death. Decedents who had both an unknown industry and an unknown occupation were excluded from our analysis of mortality rates and proportional mortality ratios (PMR) (n = 5903). The sample for our final analyses, excluding those with unknown industries or occupations, was 33 833 decedents, including 2833 (8.37%) who had a COVID-19–attributable cause of death.

Statistical Analysis

In order to evaluate the relative burden of COVID-19 mortality, chi-square tests were used to assess the proportion of COVID-19–attributable deaths compared to all other causes of death by demographic characteristics. Next, we used multivariate logistic regression to assess the likelihood of death from COVID-19 by demographics for working-age decedents. Age-adjusted mortality rates for COVID-19 were then calculated to assess the differences in burden across occupation and industry groups. Age-adjustment was used to compensate for the disproportionate representation by age in certain occupations or industries given that age is also known to be associated with COVID-19 mortality.[1] Finally, PMRs were calculated to assess within-group burden of COVID-19 mortality for occupation and industry groups. PMRs are estimated as the proportion of deaths from COVID-19 within each SOC or NAICS group divided by the proportion of deaths from COVID-19 among all workers multiplied by 100.[12] PMRs evaluate if the mortality rate for COVID-19 in a given group is significantly higher than the overall mortality rate from COVID-19 for the working-age population. PMRs greater than 100 indicate elevated COVID-19, and lower-bound confidence intervals above 100 indicate statistical significance. PMRs were considered unstable if an occupation or industry group had fewer than 15 deaths from COVID-19 or fewer than 100 deaths from all causes during the study period.

RESULTS

Demographic Analysis

Table 1 compares the proportion of COVID-19–attributable deaths to all other causes of death for Wisconsin working-age decedents during the study period. Age, race, ethnicity, and education all were associated with higher proportions of COVID-19 deaths. Those in the 3 highest age categories had significantly higher proportions of death from COVID-19, while those in the 4 lowest age categories had significantly lower proportions of death from this cause ($\chi^2 = 72.1$; $P < 0.0001$). The Asian/Pacific Islander population had more than double the proportion of COVID-19–attributable deaths than deaths from other causes ($\chi^2 = 85.9$; $P < 0.0001$) and the Hispanic population also had more than twice the proportion of COVID-19–attributable deaths as non-COVID deaths ($\chi^2 = 169.7$; $P < 0.0001$). Education was associated with COVID-19–attributable deaths, and those who had the highest levels of educational attainment (ie, advanced degrees) had a significantly lower proportion of COVID-19–attributable deaths than deaths from all other causes ($\chi^2 = 13.5$; $P = 0.0091$).

Logistic Regression Analysis

Table 2 provides the results of the logistic regression analysis, which assessed demographic differences in the likelihood of dying from COVID-19 (compared to dying of another cause) for working-age decedents in Wisconsin during the pandemic. Patterns of association were similar to those found in the cross-tabulations (Table 1). However, logistic regression controls for the variance of other factors within the model and, as such, provides a better estimate of the true associations. Age remained associated with COVID-19 mortality. Among working-age Wisconsin decedents, those in the oldest 4 age categories all had elevated likelihoods of dying from COVID-19 compared to those in the youngest age category. Those in the top 3 age groups had more than 4 times the likelihood of dying of COVID-19 (Table 2).

Table 2. Logistic Regression Analysis of Individual Characteristics Associated With COVID-19-Attributable Death – Working-age Wisconsin decedents, March 19, 2020–December 31, 2022 (N = 39 736)

	Odds Ratio	95% Wald Confidence Limits
Age		
16-19 years	reference	–
20-24 years	0.53	0.26 – 1.09
25-34 years	1.55	0.89 – 2.72
35-44 years	**2.76**	**1.60 – 4.77**
45-54 years	**4.31**	**2.52 – 7.39**
55-59 years	**4.33**	**2.53 – 7.43**
60-64 years	**4.23**	**2.47 – 7.24**
Race		
American Indian/Alaska Native	1.22	0.96 – 1.54
Asian/Pacific Islander	**3.12**	**2.52 – 3.86**
Black	1.08	0.97 – 1.20
White	reference	–
Ethnicity		
Hispanic	**2.80**	**2.46 – 3.20**
Non-Hispanic	reference	–
Unknown	0.56	0.18 – 1.81
Sex[a]		
Female	reference	–
Male	0.95	0.88 – 1.03
Education		
< High school	1.22	0.95 – 1.55
High school graduate	**1.47**	**1.17 – 1.85**
Some college, associate's, or bachelor's degree	**1.52**	**1.21 – 1.92**
Advanced degree	reference	-
Unknown/missing	**1.53**	**1.09 – 2.15**
Year		
2020	**1.25**	**1.13 – 1.38**
2021	**2.02**	**1.85 – 2.21**
2022	reference	–

[a]Excludes "Unknown" sex (n = 1).
Bold text indicates statistical significance ($P < 0.05$).

Asian/Pacific Islander individuals had more than 3 times the likelihood of dying from COVID-19 compared to their White counterparts (OR 3.12; 95% CI, 2.52-3.86) and Hispanic individuals had nearly 3 times the likelihood of dying from COVID-19 compared to non-Hispanic individuals (OR 2.80; 95% CI, 2.46-3.20). Among working-age decedents in Wisconsin, those with a high school education were 1.47 times more likely to die from COVID-19 than those with an advanced degree (ie, master's degree equivalent or higher) (OR 1.47; 95% CI, 1.17-1.85). Those who had some college, an associate's degree, or a bachelor's degree faired similarly (OR 1.52; 95% CI, 1.21-1.92). Finally, given the changes over time related to COVID-19 (eg, changes in disease detection, definitions, vaccine availability), we included time in years as a covariate in this analysis. The 2021 period was associated with the highest likelihood of COVID-19–related death for this population (OR 2.02; 95% CI, 1.85-2.21), while 2020 also was associated with a higher likelihood of dying from COVID-19 when compared to 2022 (OR 1.25; 95% CI, 1.13-1.38).

Mortality Rates by Usual Occupation and Industry

Table 3 provides counts of COVID-19–attributable deaths, ACS denominator estimates (5-year: 2017-2021), and age-adjusted mortality rates per 100 000 workers for COVID-19 by major SOC code (ie, highest level of classification) in Wisconsin for the study period. The overall age-adjusted COVID-19 mortality rate was 112.50 per 100 000 workers (95% CI, 108.67-116.32) (not shown in Table 3). The occupations with mortality rates significantly above the overall age-adjusted rate were (1) Protective Service (rate 209.55; 95% CI, 167.15-251.96), (2) Transportation and Material Moving (rate 195.86; 95% CI, 178.13-213.59), (3) Installation, Maintenance, and Repair (rate 145.11; 95% CI, 121.06-169.16), (4) Food Preparation and Serving Related (rate 141.45; 95% CI, 122.83-160.07), and (5) Healthcare Support (rate 138.68; 95% CI, 116.66-160.69). Table 3 also provides the age-adjusted COVID-19 mortality rates by 2-digit NAICS code (ie, highest level categorization). The two industries with the highest stable rates compared to the overall age-adjusted average rate were (1) Transportation and Warehousing (rate 158.40; 95% CI,

Table 3. Counts of COVID-19-Attributable Deaths, Amercian Community Survey 5-year Denominator Estimates (2017-2021), and Age-Adjusted COVID-19 Mortality Rates – Working-age Wisconsin Decedents, March 19, 2020-December 31, 2022

Major SOC Code	COVID-19-Attributable Deaths (n = 2786)	ACS Denominator Estimate (n = 2 937 652)	Age-Adjusted Rate	95% CI
Protective Service	**67**	**44,675**	**209.55**	**167.15 – 251.96**
Transportation and Material Moving	**487**	**238,866**	**195.86**	**178.13 – 213.59**
Installation, Maintenance, and Repair	**151**	**96,248**	**145.11**	**121.06 – 169.16**
Food Preparation and Serving Related	**114**	**156,475**	**141.45**	**122.83 – 160.07**
Healthcare Support	**128**	**109,774**	**138.68**	**116.66 – 160.69**
Construction and Extraction	174	137,074	133.86	114.51 – 153.22
Production	395	287,636	128.55	115.46 – 141.65
Personal Care and Service	54	63,848	110.45	84.68 – 136.21
Building and Grounds Cleaning and Maintenance	115	96,016	106.85	86.18 – 127.51
Architecture and Engineering	58	63,682	90.47	67.12 – 113.82
Arts, Design, Entertainment, Sports, and Media	39	48,797	87.32	61.11 – 113.53
Farming, Fishing, and Forestry	18	25,751	84.47	48.99 – 119.95
Sales and Related	**204**	**259,877**	**80.44**	**69.54 – 91.34**
Community and Social Service	**36**	**47,630**	**72.01**	**47.92 – 96.10**
Management	**240**	**297,461**	**68.13**	**58.75 – 77.51**
Office and Administrative Support	**230**	**315,218**	**65.50**	**56.57 – 74.43**
Computer and Mathematical	**42**	**88,202**	**62.00**	**45.57 – 78.43**
Business and Financial Operations	**74**	**157,359**	**44.11**	**33.74 – 54.49**
Healthcare Practitioners and Technical	**82**	**183,165**	**43.96**	**34.36 – 53.56**
Legal[a]	—	16,775	—	—
Education, Training, and Library	**61**	**169,287**	**37.59**	**28.36 – 46.83**
Life, Physical, and Social Science[a]	—	33,836	—	

2-Digit NAICS Code	COVID-19-Attributable Deaths (n = 2 756)	ACS Denominator Estimate (n = 2 914 232)	Age-Adjusted Rate	95% CI
Mining, Quarrying, and Oil and Gas Extraction[a]	—	4237	—	—
Transportation and Warehousing	**231**	**120 583**	**158.40**	**135.96 – 180.85**
Accommodation and Food Services	**153**	**194 529**	**151.71**	**134.42 – 169.01**
Other Services (except Public Administration)	165	116 031	134.48	113.39 – 155.57
Administration and Support and Waste Management and Remediation Services	121	99 854	128.26	106.06 – 150.46
Manufacturing	705	516 485	119.35	109.93 – 128.76
Construction	216	186 151	116.34	100.85 – 131.82
Agriculture, Forestry, Fishing and Hunting	71	56 420	115.38	87.37 – 143.40
Arts, Entertainment, and Recreation	45	52 200	109.77	81.36 – 138.17
Public Administration	96	103 038	97.29	78.26 – 116.33
Retail Trade	**243**	**311 209**	**91.33**	**80.71 – 101.94**
Utilities	**22**	**21 422**	**86.35**	**47.02 – 125.68**
Information	**34**	**45 778**	**80.90**	**54.85 – 106.94**
Health Care and Social Assistance	**312**	**433 504**	**70.84**	**62.92 – 78.76**
Finance and Insurance	**92**	**143 140**	**61.34**	**48.51 – 74.16**
Real Estate and Rental and Leasing	**25**	**34 396**	**56.97**	**31.75 – 82.19**
Wholesale Trade	**47**	**75 237**	**56.83**	**39.80 – 73.87**
Professional, Scientific, and Technical Services	**80**	**150 250**	**54.66**	**42.84 – 66.48**
Educational Services	**89**	**244 868**	**36.79**	**29.20 – 44.39**
Management of Companies and Enterprises[a]	-	4900	-	—

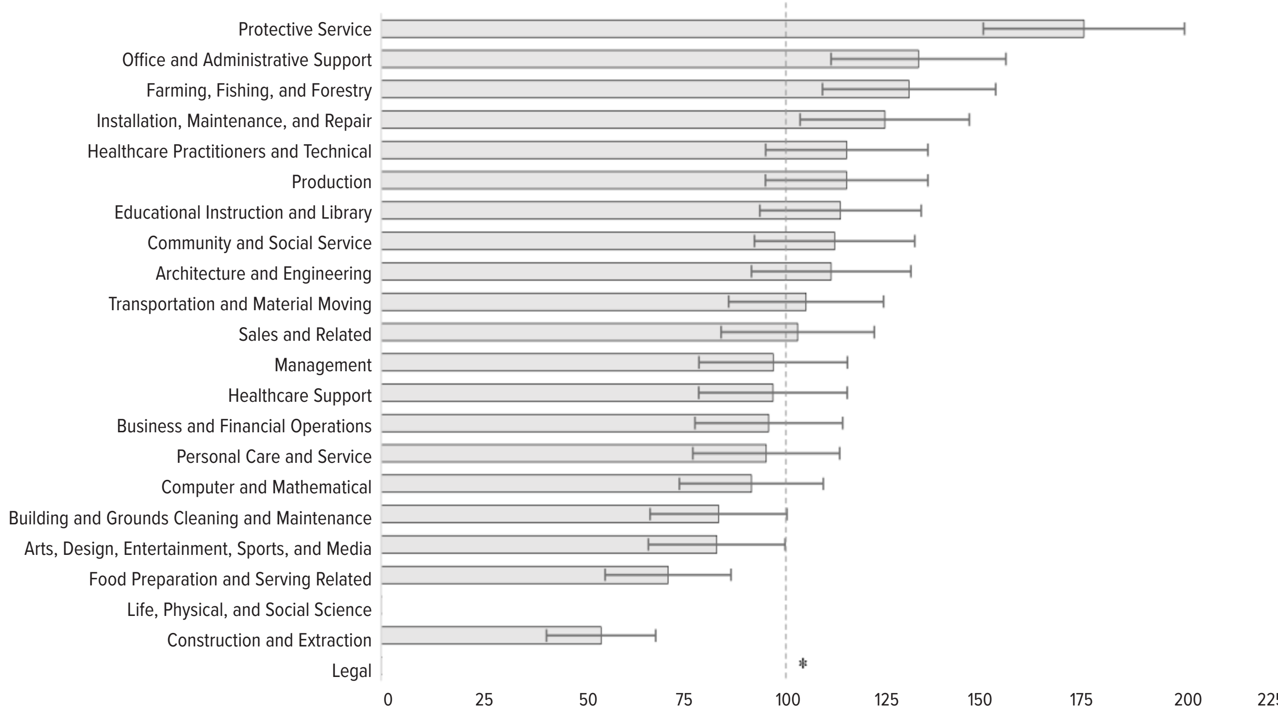
Abbreviations: ACS, American Community Survey; SOC, Standard Occupational Classification; NAICS, North American Industry Classification System

[a]Numerator < 15 and/or denominator < 100 denoting rate instability. Counts below these thresholds also suppressed in tables for confidentiality.

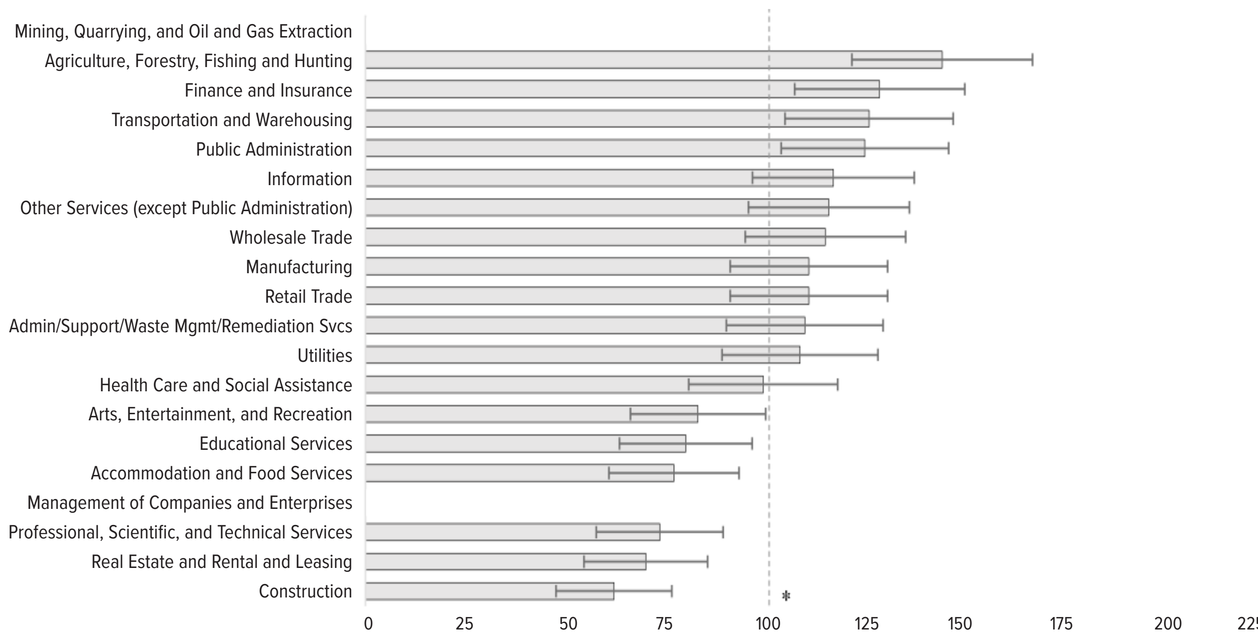
Bold text indicates statistical significance ($P < 0.05$).

Figure 1. Age-Adjusted Proportional Mortality Ratios (PMR) for COVID-19–Related Mortality, Wisconsin, March 19, 2020—December 31, 2022 (1A) by Major Standardized Occupation Classification (SOC) Code and (1B) by Two-Digit North American Industry Classification System (NAICS) Code

1A. Age-Adjusted PMRs for COVID-19–Related Mortality by Major Standardized Occupation Classification (SOC) Code



1B. Age-Adjusted PMRs for COVID-19–Related Mortality by Two-Digit North American Industry Classification System (NAICS) Code



Proportional mortality ratios over 100 indicate elevated COVID-19 mortality for a given group, and lower-bound confidence intervals above 100 indicate statistical significance. The age-adjusted PMRs were suppressed for industries and occupations with fewer than 15 death cases or 100 workers.

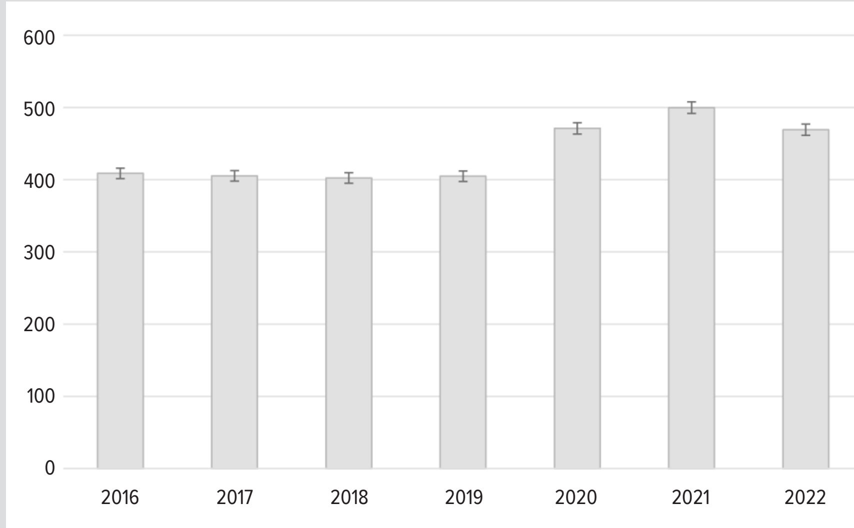
135.96-180.85) and (2) Accommodation and Food Services (rate 151.71; 95% CI, 134.42-169.01).

Proportional Mortality Ratios (PMR)

Figure 1A shows age-adjusted PMRs for occupations in Wisconsin during the pandemic as defined by major SOC codes. Four occupations had significantly elevated COVID-19 mortality during the pandemic: (1) Protective Service (PMR 173.67; 95% CI, 148.80-200.43), (2) Office and Administrative Support (PMR 132.80; 95% CI, 111.18-156.32), (3) Farming, Fishing, and Forestry (PMR 130.47; 95% CI, 109.04-153.79), and (4) Installation, Maintenance, and Repair (PMR 124.48; 95% CI, 103.57-147.28).

Figure 1B shows age-adjusted PMRs for industry sectors in Wisconsin during the study period as defined by 2-digit NAICS codes. Four industries had significantly elevated PMRs: (1) Agriculture, Forestry, Fishing and Hunting (PMR 144.05; 95% CI, 121.49-168.51), (2) Finance and Insurance (PMR 128.45; 95% CI, 107.20-151.60), (3) Transportation and Warehousing (PMR 125.82; 95% CI, 104.79-148.73), and (4) Public Administration (PMR 124.76; 95% CI, 103.83-147.58).

Figure 2. Age-Adjusted All-Cause Mortality Rate per 100 000 Among Working-Age Adults, Wisconsin, 2016-2022



DISCUSSION

Demographic Disparities

These findings expand our understanding of the relationship between demographics, work, and COVID-19 mortality in Wisconsin. Our logistic regression showed that working-age Asian/Pacific Islander individuals in Wisconsin were more than 3 times as likely to die of COVID-19 when compared to their working-age White counterparts. Additionally, working-age Hispanic individuals in Wisconsin had nearly 3 times the likelihood of dying from COVID-19 compared to their non-Hispanic peers. While disparities between Black and White Wisconsin residents were indicated by data early in the pandemic,[5] they were not found in our analysis. While we lacked the statistical power to assess racial and ethnic differences within industry and occupation groups, the literature shows that there are differences in distribution of race by industry and occupation.[12] We may see indications of these relationships in other components of our analyses as well. For instance, Farming, Fishing, and Forestry occupations had a significantly elevated PMR, as did the Agriculture, Forestry, Fishing, and Hunting industry. Both of these classifications tend to have large proportions of Hispanic workers.[12,23]

The relationship between age and COVID-19 mortality is established,[1] but the correlation with education has been less well documented.[24] Certainly, education and occupation are intertwined components of socioeconomic status, and those with the highest levels of education are the most likely to have been able to take precautions to prevent exposure to COVID-19 (eg, working from home, avoiding contact with strangers) and to have had better health pre-infection and better access to care. Such factors are likely to reduce the COVID-19 mortality for these individuals. This is reflected in our findings that, by and large, those with lower education levels had higher likelihoods of COVID-19 mortality than those who had advanced degrees (ie, master's degree equivalent or higher). As education is not an equitably distributed good in society, these differences point to disparities that need to be recognized.

Comparison Between Incidence and Mortality

Our findings on mortality rates differed from what might be expected from previously published findings on work-related incidence of COVID-19 for workers in Wisconsin.[14] While we found high mortality rates for several occupations, including Protective Service, Food Preparation and Serving-Related, and Health Care Support – all of which also had high incidence of COVID-19 – we did not find high mortality among other occupations associated with high incidence (ie, Personal Care and Service, Buildings and Grounds Cleaning and Maintenance). Similar patterns were found with industries. Our findings indicated high mortality rates for Accommodations and Food Service and for Other Services (except Public Administration), which each had high incidence rates – but we did not find elevated mortality rates among other high incidence industries (ie, Health Care and Social Assistance, Public Administration, and Utilities). Resolving discrepancies between incidence and mortality is complicated but potentially instructive. For instance, individuals in the Health Care and Social Assistance industry may have high incidence and low mortality because while they were more likely to be exposed to the virus, they also were more likely to be tested, to have access to personal protective equipment, and to be among the first individuals vaccinated – all of which may have resulted in lower mortality. Looking for ways to resolve these differences can lead to hypotheses that may be tested with future analyses.

Proportional Mortality Ratios

PMRs provided additional information and indicated the industries with the highest relative burden of COVID-19. Some occupations and industry groups (eg, Protective Service, Transportation and Warehousing) had both elevated mortality rates and elevated PMRs in our analyses, indicating that COVID-19 was a leading cause of mortality for these groups. However, the patterns were not always so consistent. For instance, Farming, Fishing, and Forestry occupations had the lowest incidence in the Pray et al analysis.[14] Our analyses found a slightly below average overall mortality rate for that group (Table 3) but a significant PMR (Figure 1B), suggesting elevated COVID-19–related mortality. These findings were paralleled with a related industry group – Agriculture, Forestry, Fishing, and Hunting – which was the lowest industry in terms of COVID-19 incidence in the Pray et al analysis.[14] In our analyses, we found a somewhat below average mortality rate for this group (Table 3) but a significantly elevated PMR (Figure 2B). While we cannot say for certain why we see these differences, it is possible that individuals in these industries were less likely to be tested for COVID-19 and, therefore, underrepresented in the incidence data, which would, in turn, artificially suppress the incidence rate for these groups. Additionally, as mentioned above, a large percentage of these individuals were likely Hispanic.[23] As such, these workers may have had a harder time getting information due to language barriers or an absence of trusted information sources.[25]

Limitations and Sensitivity Analyses

There are several limitations in our analyses worth noting. First, while we had data on occupation for decedents, this was usual occupation and not necessarily the current occupation. As such, it may be that some individuals were not employed or working in their usual occupation or industry at the time of death. Second, we have no way of knowing if the virus was transmitted via work or not, and while our data show rates of COVID-19 mortality, they do not reveal causation. Rates for each occupation or industry are likely to be affected by social or behavioral risk factors unrelated to the specific work setting. It is also a limitation that we used high-level categories (ie, major SOC and 2-digit NAICS codes) to assess industries and occupations, as this may mask important intragroup differences.

Another potential limitation is how inclusive we were when defining mortality from COVID-19 (ie, including all contributing causes of death). We believe our choice is defensible given CSTE's interim guidance for classification of COVID-19-associated deaths[22] and the novelty of the virus. Still, the risk of our approach is that we may have included some deaths that were not truly attributable to COVID-19. Should that be the case, however, the additional variance would likely make it more difficult to detect an effect. Given that the effects we show are robust to this potential source of additional variance, we believe our estimates are conservative. Moreover, we conducted a sensitivity analysis of mortality rates using a more restrictive definition and found no meaningful differences (data not shown). While the rank order of the mortality rates changed slightly, the same SOC and NAICS codes were associated with elevated rates. That said, it remains possible that we failed to detect effects that were important, and future analyses may consider a different approach to defining mortality from COVID-19.

Finally, it is a limitation that PMRs are estimated relative to the count and distribution of all deaths[12] and, as such, if there was a meaningful decrease in deaths from other causes during the pandemic, COVID-19 mortality could appear artificially elevated (ie, by supplanting these missing deaths). In consideration of this, we inspected the overall age-adjusted mortality rates per 100 000 working-age adults in Wisconsin during 2016-2022, which suggests a relatively stable year-over-year trend in mortality with significant increases during the pandemic (Figure 2). This is consistent with COVID-19 contributing additional mortality.

CONCLUSIONS

This study represents an important step in our continued understanding of COVID-19 and COVID-19 mortality in Wisconsin. Usual occupation and industry were associated with differential mortality, and some groups had a significant burden of COVID-19 mortality. The lessons of this recent pandemic are important for the future of public health and worker safety, though it is important to keep in mind that future pandemics may affect the population differently with regards to demographics (ie, who is at higher risk). That said, understanding who bore disparate risks of death in the COVID-19 pandemic provides a starting place to prepare, communicate, and mitigate risks to workers in the future. It is important to note the inequities that our findings indicate. Many demographically defined populations (eg, older individuals, people who are Hispanic or Asian/Pacific Islanders, and those with lower educational attainment) were found to have higher rates of COVID-19 mortality. These populations should be considered when creating policies, communication strategies, and mitigation or prevention plans.

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