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Sex Differences in COVID-19 Deaths, by Industry and Occupation, 2021

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Abstract

Introduction: The COVID-19 pandemic has disproportionately impacted workers in certain industries and occupations. The infection risk for SARS-CoV-2 and future respiratory viruses in the workplace is a significant concern for workers, employers, and policymakers. This study describes the differences in COVID-19 mortality by sex and industry/occupation among working-age U.S. residents in 49 states and New York City.

Methods: The 2021 National Vital Statistics System public use multiple-cause-of-death data for U.S. decedents aged 15–64 years (working age) with information on usual industry and occupation were analyzed in 2022. Age-standardized COVID-19 death rates for selected demographic characteristics and adjusted proportional mortality ratios were estimated by sex and usual industry and occupation.

Results: In 2021, 133,596 (14.3%) U.S. decedents aged 15–64 years had COVID-19 listed as the underlying cause of death; the highest COVID-19 death rate was among persons aged 55–64 years (172.4 of 100,000 population) and males (65.5 of 100,000 population). Among males and females, American Indian or Alaskan Native and Black or African American, respectively, had the highest death rates. Hispanic males had higher age-adjusted death rates than Hispanic females. Working-age male decedents in the public administration (proportional mortality ratio=1.39) and management of companies and enterprises industries (proportional mortality ratio=1.39) and community and social services occupations (proportional mortality ratio=1.68) and female decedents in the utilities industry (proportional mortality ratio=1.20) and protective services occupation (proportional mortality ratio=1.18) had the highest proportional mortality ratios.

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Conclusions: COVID-19 death rates and proportional mortality ratios varied by sex, industry, and occupation groups. These findings underscore the importance of workplace public health interventions, which could protect workers and their communities.

INTRODUCTION

Work is a key social determinant of health; workplace and worker risk factors in certain work environments can facilitate the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes coronavirus disease 2019 (COVID-19).^{1–3} Previous studies suggest that workers in the healthcare, protective services (police officers, correctional officers, and firefighters), office and administrative support, social services, food services, and maintenance occupations had a high risk of exposure to SARS-CoV-2.^{3–6} An estimated 75% (108.4 million) of workers are employed in occupations not conducive to working from home or telework and are at increased risk for exposure to infectious agents and adverse health outcomes.⁴ Working conditions, type of work, job tasks, and interactions with the public while at work as well as baseline health conditions vary by industry and occupation and have influenced exposure to infectious agents and transmission of SARS-CoV-2.^{5–7} COVID-19 caused major health impacts and economic burden (e.g., medical expenses, wage loss, and lost work time).^{5,6,8} The COVID-19 pandemic has disproportionately affected workers in certain industries and occupations.^{3,7}

Disparities in COVID-19 mortality among working-age (15–64 years) adults have been reported previously.³ In 2020, among working-age U.S. residents, 8% of all deaths were attributed to COVID-19, and the death rates and proportional mortality ratios (PMRs) were significantly elevated among certain groups of decedents, including workers in certain industries and occupations.³ Male decedents in community and social service occupations and healthcare and social assistance industries and female decedents in the farming, fishing, and forestry occupations and agriculture; forestry, fishing, and hunting; and healthcare and social assistance industries had the highest PMRs.³

Overall, the number of deaths and fatality rates due to COVID-19 has been declining in the U.S., and this could be associated with increased COVID-19 vaccine coverage, immunity after natural infection, personal protective equipment (PPE) use, implementation of engineering controls (e.g., improving ventilation) and administrative policies (e.g., vaccination policies), and physical distancing combined with the availability of tests and treatments.^{9–11} These measures have been highly effective in preventing COVID-19–associated severe illness, hospitalization, and death.^{7,9} Although COVID-19 deaths have been declining in the U.S., COVID-19 remains an important public health concern among the U.S. population and was among the top 3 leading causes of death in 2021.¹⁰ This study describes the overall COVID-19 deaths in 2021 and sex-specific differences in COVID-19 death rates, age-adjusted death rates, and PMRs among working-age adults (15–64 years) by usual industry and occupation.

METHODS

Study Sample

The 2021 National Vital Statistics System multiple-cause-of-death data restricted to U.S. decedents aged 15–64 years (working age) with usual occupations and industries from 50 jurisdictions, including New York City (reports data independently from New York State) and 49 states, excluding both District of Columbia and Rhode Island,^{3,12} were analyzed (N=933,960 decedents). Of those, 144,023 decedents had COVID-19 listed as an underlying or contributing cause of death (any mention). For this study, only decedents with COVID-19 listed as an underlying cause of death ($n=133,596$; 93%) were examined. IRB approval was exempted under the Common Rule (45 CFR x46) because deidentified and publicly available data were used for analysis.

Measures

COVID-19 was identified using the ICD-10 code U07.1. The underlying cause of death is the disease or condition responsible for initiating the chain of events leading directly to death. The U.S. standard certificate of death includes the usual industry and occupation field for narratives in which the decedent spent most of their working life. The National Vital Statistics System multiple-cause-of-death public use data include the usual occupation/industry groups, which were autocoded into standardized individual U.S. Census Bureau occupation and industry codes using the National Institute for Occupational Safety and Health Industry and Occupation Computerized Coding System (NIOCCS).^{12,13} NIOCCS is a publicly available system, and since 2021, it has incorporated machine learning to improve coding uniformity.¹³ For quality check after the NIOCCS program completes initial coding, the data are further reviewed manually by expert National Institute for Occupational Safety and Health coding staff for (1) code review, (2) quality control review, and (3) consistency review (to detect intra-coder differences).¹² Further details on the industry/occupation groups and coding methods are described elsewhere.¹² The usual industry is the type of business or industry that the decedent worked in during most of their life or for the longest time; usual occupation is the occupation the person did for most of their working life.^{3,12} For this study, decedents with information on their usual industry and occupation were considered employed. The simple 20 two-digit industry groups were based on the 2012 North American Industry Classification System, and the simple 20 two-digit occupation groups were based on the 2010 Standard Occupational Classification–informed codes.¹² Industry and occupation narratives were not coded for deaths in the District of Columbia and Rhode Island. Therefore, working-age adults in these 2 jurisdictions were excluded from the current analysis.

Statistical Analysis

Age-specific and age-adjusted COVID-19 death rates and adjusted PMRs for COVID-19 were estimated. Death rates (per 100,000 population [aged 15–64 years]) were based on postcensal population estimates as of July 1, 2021. Age-adjusted rates were determined by applying age-specific death rates to the 2000 U.S. Census standard population.¹⁴ PMRs were calculated by industry, occupation, and sex. PMR evaluates the relative COVID-19 mortality using a ratio of 2 proportions, estimated as the proportion of deaths from COVID-19 within

each industry or occupation group of interest (numerator) compared with the proportion of deaths from COVID-19 among all persons aged 15–64 years (denominator); this includes decedents aged 15–64 years with unreported or nonpaid industries/occupations and those who may have retired. For example, the unadjusted COVID-19 PMR among working-age decedents in the utilities industry is estimated as follows:

$$\text{PMR} = \frac{\left(\frac{\text{COVID-19 decedents among utilities industry}}{\text{Total decedents among utilities industry}} \right)}{\left(\frac{\text{COVID-19 decedents among working-age persons}}{\text{Total decedents among working-age persons}} \right)}$$

PMRs were adjusted for age, sex, race, and ethnicity. A $\text{PMR} > 1.0$ indicates that more deaths are associated with the condition in a specified industry or occupation than expected. CIs were calculated assuming a Poisson distribution of the data. Data were analyzed using SAS (version 9.4; SAS Institute, Cary, NC).

RESULTS

In 2021, of the 933,960 working-age (15–64 years) decedents from 50 U.S. jurisdictions, 133,596 (14.3%) had COVID-19 listed as the underlying cause of death (Table 1). COVID-19 listed as an underlying cause of death covered 93% of all deaths with any mention of COVID-19 among working-age decedents ($n=144,023$ underlying/contributing cause). Total number of COVID-19 deaths increased with age, and >50% of all COVID-19 deaths were observed among persons aged 55–64 years (Table 1). By sex, the age-adjusted death rate was significantly higher among males (65.5 per 100,000 population) than among females (41.0 per 100,000 population; $p < 0.05$), and COVID-19 death rates varied by age group, race, and ethnicity. COVID-19 death rates were highest among American Indian or Alaska Native (50.5 per 100,000 population) and Hispanic males (106.3 per 100,000 population) than among females of the same race/ethnicity (36.7 per 100,000 population and 47.8 per 100,000 population, respectively; $p < 0.05$). Among females, Black or African Americans (31.6 per 100,000 population) had the highest age-adjusted COVID-19 death rates (Table 1).

Overall, working-age decedents in 11 industries and 13 occupations had significantly ($p < 0.05$) elevated adjusted PMRs (Tables 2 and 3). The highest COVID-19 PMRs were in the management of companies and enterprises ($\text{PMR}=1.34$), in the mining ($\text{PMR}=1.30$) and utilities ($\text{PMR}=1.30$) industries, and in the protective services ($\text{PMR}=1.39$) and community and social services occupations ($\text{PMR}=1.37$).

The industry- and occupation-specific PMRs varied by sex. Among males, the public administration ($\text{PMR}=1.39$), management of companies and enterprises industries ($\text{PMR}=1.39$), and community and social services occupations ($\text{PMR}=1.68$) had the highest PMR. Among females, PMRs were highest in the utilities industry ($\text{PMR}=1.20$) and protective services occupation ($\text{PMR}=1.18$).

DISCUSSION

In 2021, of the 933,960 working-age U.S. decedents aged 15–64 years in 50 jurisdictions, 14.3% of decedents had COVID-19 listed as the underlying cause of death, and >80% of these decedents were aged 45–64 years. Similar to previous findings, the highest age-specific rates were among decedents aged >55–64 years, males, Hispanics, and American Indian and Alaskan Natives.^{3,15} The age-adjusted COVID-19 death rates were significantly higher for males than for females. Among males, American Indian or Alaskan Native and Hispanic decedents had high age-adjusted death rates, and among females, Black or African Americans had the highest adjusted death rates. Previous findings indicate that Black or African Americans were most likely to be employed in industries and occupations with frequent exposure to the SARSCoV-2 virus and elevated risk factors such as working in close proximity to other workers and the public.^{15–17} Mortality differences may be partially due to demographic, educational, or geographic disparities in vaccine acceptance and hesitancy to receive the COVID-19 vaccines.^{15,16,18,19} Other factors, including sex-related health behaviors, the timing of COVID-19 surges, health policies, race, income, access to health care, and the type of job, have been associated with differences in COVID-19 morbidity and mortality.^{15,17,20}

In this study, disparities in COVID-19 mortality among working-age decedents were similar to those previously reported. Billock et al. found significantly elevated PMRs in the transportation and warehousing, healthcare and social services, management, administrative and waste services industry workers and among workers in the community and social services, protective services, personal care services, and transportation and material moving occupations.³ Workers in most of these industries/occupations (healthcare workers, public administration workers, mining accommodation and food services, and protective service workers) were considered essential during the COVID-19 pandemic.^{20–22} Essential workers were required to continue working during the pandemic, often in person and in close contact with coworkers or the public, and were considered essential to critical infrastructure.^{20,23} In 2020, essential workers had higher COVID-19 death rates than those employed in nonessential positions.^{21,22} Some of these differences may be associated with vaccine hesitancy.^{24,25} Lower vaccination acceptance rates were reported among workers employed in the following occupations: construction and extraction trade (45.7%); installation, maintenance, and repair (52.1%); transportation and material moving (60.6%); protective services (63.1%), including police and sheriff officers; and production workers (63.6%).^{24,25} Moreover, workers in some occupations (transportation and warehousing, emergency responders, protective services, and meat and poultry processing workers) are racially diverse, low-wage workers whose jobs may require close interaction with the public or work in close proximity to their coworkers and who had language barriers, long work hours, and limited availability of PPE, placing them at increased risk of COVID-19 infection.^{20,26–28} SARS-CoV-2 is transmitted through aerosol, and differences in the implementation of workplace safety measures, such as availability and proper use of effective PPE, adequate ventilation in workplace settings, maintaining appropriate physical distancing, sick leave policies, and vaccine uptake, may partially explain the lower mortality COVID-19 deaths in certain industries and occupations.^{27,28}

Sex differences in COVID-19 deaths were observed among decedents in certain industries and occupations, similar to previous findings.³ Working-age male decedents had significantly higher COVID-19 PMRs in more than half of the examined industries and occupations, and the PMRs varied by sex. Among male decedents, the public administration and management of companies and enterprises (including workers in the trucking, warehousing, research and developments, administering, and overseeing and managing programs and public administration) and community and social services occupations had the highest COVID-19 PMRs. Among female decedents, the utilities industry and protective services occupation had the highest COVID-19 PMRs. A majority of essential workers in the occupations (transportation and material moving, production, construction and extractions, installation and material moving, and protective services, among others) with high COVID-19 PMRs were males, as previously reported.²⁰ In addition, females in the personal care services (62% were females) had significantly higher COVID-19 PMR than males. Differences by sex in sociodemo-graphic characteristics, health behaviors, preexisting health status, job type, and vaccination coverage may partially explain the variations in PMRs by industry and occupation.^{15,16,27} Higher odds of COVID-19 testing and diagnosis were observed among male healthcare workers than among females.²⁹ A study evaluating healthcare workers in Ontario, Canada from March to July 2020 attributed 31% of the COVID-19 cases to occupational exposures, 59% were attributed to staff-to-staff contact, and 41% were considered as acquired from a patient.³⁰

Occupational exposures to the SARS-CoV-2 virus and differences in COVID-19 vaccination rates have been reported as important contributors to disparities in COVID-19 mortality.²⁵ Promoting confidence in vaccines and reducing barriers to access are needed to protect workers from severe health consequences of vaccine-preventable diseases.^{25,30,31} Furthermore, the findings from this study could help guide targeted public health messaging and prompt public health risk response and management for COVID-19 and other similar illnesses with high morbidity and mortality or pandemics with respiratory transmission in the workplace, thus mitigating the impact of future outbreaks.^{4,31,32}

Limitations

The findings in this report are subject to limitations. COVID-19 deaths were not validated using medical records. No information on employment status at the time of death or workplace exposures is available on death certificates. Therefore, it is unknown whether workplace exposures could have led directly to COVID-19 death. Moreover, the usual industry and occupation information reported on the death certificate may not be the industry and occupation in which workplace exposures might have occurred. Workplace exposure risk may depend on the job type, and other factors, including difficulty in determining where SARS-CoV-2 infection occurred, lack of testing, misdiagnosis of COVID-19 as other respiratory diseases such as pneumonia or influenza, and limited data on workplace infection or outbreak information, could have contributed to underreporting of COVID-19 deaths. Many decedents aged ≥ 65 years could have been working during the pandemic and were excluded from the current analysis. PMRs were calculated because no denominator data were available to calculate risk in industry and occupation subgroups because the decedent's usual industry and occupation collected on the death certificate

may not be the same as their current industry and occupation, which is typically captured on population-level surveys. PMR measures the relative cause-specific mortality, and the estimates are relative to the number and distribution of all deaths within a given industry or occupation. Therefore, PMR differences by population explain the differences in the proportion of deaths from the cause of interest rather than absolute risk. However, previous findings have shown that industry-/occupation-specific PMRs calculated were similar to the death rates.³ Finally, results are limited to 50 jurisdictions and may not represent the nonparticipating jurisdictions.

CONCLUSIONS

Disparities in COVID-19 mortality among working-age (15–64 years) decedents by sex and usual industry and occupations exist among certain population groups. These findings underscore the importance of implementing multilayered interventions in the workplace to prevent severe COVID-19 by improving vaccination rates, protecting unvaccinated and otherwise at-risk workers, and mitigating the spread of COVID-19. Prevention programs, including engineering controls (e.g., ventilation), administrative controls (e.g., vaccination policies; sick leave policies; physical distancing, including through the use of telework and flexible schedules), PPE, and enhanced cleaning programs with a focus on high-touch surfaces, are essential to preventing COVID-19 in the workplace.^{32,33} In addition, once infected, access to tertiary prevention through prompt, appropriate diagnosis and medical treatment is critical to improving outcomes and reducing COVID-19 mortality. Additional up-to-date information on COVID-19 vaccines and industry-specific health regulations can be accessed from the Occupational Safety and Health Administration website.³³

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REFERENCES

1. The community guide 2022. Advancing Health Equity. The Community Guide. Accessed October 17, 2023. <https://www.thecommunity-guide.org/pages/advancing-health-equity.html>.
2. Armenti K, Sweeney MH, Lingwall C, Yang L. Work: a social determinant of health worth capturing. *Int J Environ Res Public Health*. 2023;20(2):1199. 10.3390/ijerph20021199. [PubMed: 36673956]
3. Billock RM, Steege AL, Miniño A. COVID-19 mortality by usual occupation and industry:46 states and New York City, United States, 2020. *Natl Vital Stat Rep*. 2022;71(6):1–33. Accessed October 17, 2023.

4. Baker MG, Peckham TK, Seixas NS. Estimating the burden of United States workers exposed to infection or disease: a key factor in containing risk of COVID-19 infection. *PLoS One*. 2020;15(4):e0232452. 10.1371/journal.pone.0232452. [PubMed: 32343747]
5. Carlsten C, Gulati M, Hines S, et al. COVID-19 as an occupational disease. *Am J Ind Med*. 2021;64(4):227–237. 10.1002/ajim.23222. [PubMed: 33491195]
6. Sandal A, Yildiz AN. COVID-19 as a recognized work-related disease: the current situation worldwide. *Saf Health Work*. 2021;12(1):136–138. 10.1016/j.shaw.2021.01.001. [PubMed: 33520326]
7. Hawkins D, Davis L, Kriebel D. COVID-19 deaths by occupation, Massachusetts, March 1–July 31, 2020. *Am J Ind Med*. 2021;64 (4):238–244. 10.1002/ajim.23227. [PubMed: 33522627]
8. Baker MG. Nonrelocatable occupations at increased risk during pandemics: United States, 2018. *Am J Public Health*. 2020;110(8):1126–1132. 10.2105/AJPH.2020.305738. [PubMed: 32552016]
9. Centers for Disease Control and Prevention. COVID-19 data review: update on COVID-19 related mortality. CDC. Accessed October 17, 2023. <https://www.cdc.gov/coronavirus/2019-ncov/science/data-review/risk.html>
10. Xu JQ, Murphy SL, Kochanek KD, Arias E. Mortality in the United States. *NCHS Data Brief*. 2022;(456):1–8. Accessed October 17, 2023.
11. Asfaw A, Bushnell T, Alterman T, Pana-Cryan R. QuickStats: percentage* of employed adults who needed to work closer than 6 feet from other persons all or most of the time at their main job,^y by occupation^x—National Health Interview Survey, United States, July–December 2020. *MMWR Morb Mortal Wkly Rep*. 2021;70(49):1718. 10.15585/mmwr.mm7049a7. [PubMed: 34882656]
12. Steege AL, Billock R, Miniño A. Industry and Occupation (I&O) data as applicable to mortality vital statistics, 2020: History, background, and control tables. Hyattsville, MD: National Center for Health Statistics. 2021. Available from: <https://www.cdc.gov/nchs/data/dvs/industry-and-occupation-data-mortality-2020.pdf>
13. Industry and Occupation Computerized Coding System (NIOCCS); 2023. U.S. Department of Health and Human Services Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Field Studies & Engineering, Health Informatics Branch. Accessed October 17, 2023 <https://csams.cdc.gov/nioccs/About.aspx>
14. Klien RJ, Schoenborn CA. Age adjustment using the 2000 projected U.S. population. *Healthy People Stat Notes*, 2001;20:1–10. Accessed on October 17, 2023. <https://www.cdc.gov/nchs/data/statnt/statnt20.pdf>
15. Danielsen AC, Lee KMN, Boulicault M, et al. Sex disparities in COVID-19 outcomes in the United States: quantifying and contextualizing variation. *Soc Sci Med*. 2022;294:114716. 10.1016/j.socscimed.2022.114716. [PubMed: 35042136]
16. Hawkins D Differential occupational risk for COVID-19 and other infection exposure according to race and ethnicity. *Am J Ind Med*. 2020;63(9):817–820. 10.1002/ajim.23145. [PubMed: 32539166]
17. Chen YH, Glymour M, Riley A, et al. Excess mortality associated with the COVID-19 pandemic among Californians 18–65 years of age, by occupational sector and occupation: march through November 2020. *PLoS One*. 2021;16(6):e0252454. 10.1371/journal.pone.0252454. [PubMed: 34086762]
18. Malik AA, McFadden SM, Elharake J, Omer SB. Determinants of COVID-19 vaccine acceptance in the U.S. *EClinicalmedicine*. 2020;26:100495. 10.1016/j.eclinm.2020.100495. [PubMed: 32838242]
19. Momplaisir FM, Kuter BJ, Ghadimi F, et al. Racial/ethnic differences in COVID-19 vaccine hesitancy among health care workers in 2 large academic hospitals. *JAMA Netw Open*. 2021;4(8):e2121931. 10.1001/jamanetworkopen.2021.21931. [PubMed: 34459907]
20. Blau FD, Koebe J, Meyerhofer PA. Who are the essential and frontline workers? *Bus Econ*. 2021;56(3):168–178. 10.1057/s11369-021-00230-7. [PubMed: 34253931]
21. Chen Y, Chen R, Charpignon M, et al. COVID-19 mortality among working-age Americans in 46 states, by industry and occupation. *medRxiv*. 2022 2022–03. 10.1101/2022.03.29.22273085.

22. Nguyen LH, Drew DA, Graham MS, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. *Lancet Public Health*. 2020;5(9):e475–e483. 10.1016/S2468-2667(20)30164-X. [PubMed: 32745512]
23. U.S. Department of Homeland Security. Advisory memorandum on ensuring essential critical infrastructure workers' ability to work during the COVID-19 response, version 4.1. https://www.cisa.gov/sites/default/files/publications/essential_critical_infrastructure_workforce-guidance_v4.1_508.pdf. Updated August 10, 2021. Accessed August 15, 2023.
24. King WC, Rubinstein M, Reinhart A, Mejia R. COVID-19 vaccine hesitancy January–May 2021 among 18–64 year old U.S. adults by employment and occupation. *Prev Med Rep*. 2021;24:101569. 10.1016/j.pmedr.2021.101569. [PubMed: 34603943]
25. Henneberger P, Cox-Ganser JM, Guthrie GM, Groth CP. Estimates of COVID-19 vaccine uptake in major occupational groups and detailed occupational categories in the United States, April–May 2021. *Am J Ind Med*. 2022;65(7):525–536. 10.1002/ajim.23370. [PubMed: 35587657]
26. Gaitens J, Condon M, Fernandes E, McDiarmid M. COVID-19 and essential workers: A narrative review of health outcomes and moral injury. *Int J Environ Res Public Health*. 2021;18(4):1446. 10.3390/ijerph18041446. [PubMed: 33557075]
27. Chen YH, Riley AR, Duchowny KA, et al. COVID-19 mortality and excess mortality among working-age residents in California, USA, by occupational sector: a longitudinal cohort analysis of mortality surveillance data. *Lancet Public Health*. 2022;7(9):e744–e753. 10.1016/S2468-2667(22)00191-8. [PubMed: 36057273]
28. Wong J, Cummings KJ, Gibb K, Rodriguez A, Heinzerling A, Vergara XP. Risk factors for COVID-19 among Californians working outside the home, November 2020 – May 2021. *Am J Ind Med*. 2023;66 (3):233–242. 10.1002/ajim.23459. [PubMed: 36694299]
29. Ballering AV, Oertelt-Prigione S, Olde Hartman TC, Rosmalen JGM, Lifelines Corona Research Initiative. Sex and gender-related differences in COVID-19 diagnoses and SARS-CoV-2 testing practices during the first wave of the pandemic: the Dutch lifelines COVID-19 cohort study. *J Womens Health (Larchmt)*. 2021;30(12):1686–1692. 10.1089/jwh.2021.0226. [PubMed: 34473580]
30. Spilchuk V, Arrandale VH, Armstrong J. Potential risk factors associated with COVID-19 in health care workers. *Occup Med (Lond)*. 2022;72(1):35–42. 10.1093/occmed/kqab148. [PubMed: 34729600]
31. Nguyen KH, Zhao R, Chen S, Bednarczyk RA. Exclusive and dual influenza and COVID-19 vaccination among U.S. adults and adolescents in 2021. *Ann Med*. 2023;55(1):2196436. 10.1080/07853890.2023.2196436. [PubMed: 37052255]
32. U.S. Department of Labor. Occupational Safety and Health Administration. Protecting workers: guidance on mitigating and preventing the spread of COVID-19 in the workplace. <https://www.osha.gov/coronavirus/safework>. Updated June 10, 2021. Accessed August 15, 2023.
33. U.S. Department of Labor. Occupational Safety and Health Administration. Coronavirus disease (COVID-19). <https://www.osha.gov/coronavirus>. Accessed August 14, 2023.

Table 1. COVID-19 Death Rates Among Working-Age Adults by Sex and Selected Characteristics, 50 U.S. Jurisdictions, 2021

Characteristics	COVID-19 deaths									
	Males				Females				Total	
	Underlying cause of death ^a n (%)	Death rate ^b (per 100,000)	Age-adjusted death rate ^c (95% CI)	Underlying cause of death ^a n (%)	Death rate ^b (per 100,000)	Age-adjusted death rate ^c (95% CI)	Underlying cause of death ^a n (%)	Death rate ^b (per 100,000)	Age-adjusted death rate ^c (95% CI)	
Total	82,550 (13.9)	76.7	65.5 (64.6, 6.5)	51,046 (14.9)	47.8	41.0 (40.3, 41.4)	133,596 (14.3)	62.3	53.4 (52.8, 54.0)	
Age group, year										
15–24	836 (3.0)	3.8	—	560 (5.4)	2.7	—	1,396 (3.7)	3.3	—	
25–34	3,860 (6.7)	16.9	—	2,251 (9.3)	10.1	—	6,111 (7.5)	13.5	—	
35–44	9,902 (12.2)	45.6	—	6,039 (14.0)	28.2	—	15,941 (12.8)	36.9	—	
45–54	23,329 (17.3)	115.4	—	13,407 (16.8)	66.1	—	36,736 (17.1)	90.7	—	
55–64	44,623 (15.3)	214.0	—	28,789 (15.6)	132.5	—	73,412 (15.4)	172.4	—	
Race										
White	64,801 (14.4)	47.8	40.6 (39.9, 41.4)	36,822 (14.5)	22.8	19.4 (19.0, 19.8)	24,167 (14.5)	63.0	53.6 (52.9, 54.3)	
Black or African American	12,892 (11.4)	43.0	34.3 (33.0, 35.6)	11,275 (16.1)	37.6	31.6 (30.3, 32.8)	14,083 (13.2)	80.7	66.1 (64.2, 67.9)	
American Indian or Alaska Native	1,447 (16.0)	50.5	40.8 (36.6, 45.0)	1,052 (18.0)	36.7	30.9 (27.2, 34.6)	56,237 (16.8)	87.2	72.0 (66.4, 77.6)	
Asian or Pacific Islander	2,761 (17.7)	18.9	14.8 (13.6, 16.0)	1,509 (13.6)	10.3	7.5 (6.7, 8.4)	337,237 (17.4)	29.2	23.3 (21.8, 24.8)	
Multiple Ethnicity	649 (11.3)	11.8	—	388 (11.7)	—	—	2,216 (11.4)	18.8	—	
Ethnicity										
Hispanic	21,641 (24.6)	106.3	82.7 (80.2, 85.2)	10,223 (25.4)	47.8	37.3 (35.7, 38.8)	31,864 (24.9)	76.3	56.6 (55.3, 58.0)	
Non-Hispanic	60,764 (12.1)	70.4	58.5 (57.5, 59.5)	40,742 (13.6)	47.3	41.3 (40.5, 42.2)	101,506 (12.6)	53.6	43.6 (43.0, 44.1)	
Unknown	145 (6.8)	—	—	81 (10.5)	—	—	226 (7.8)	—	—	

Data source: NVSS public use multiple cause files 2021.

Working-age U.S. residents were those aged 15–64 years from 49 jurisdictions (excluding the District of Columbia and Rhode Island) with information on their usual industry and occupation.

^aNumber and proportion of decedents with COVID-19 (ICD-10 Code U07.1) (death certificate-based ICD-10 diagnosis codes for COVID-19 mortality surveillance—U.S., January–December 2020 [cdc.gov]) listed as the underlying cause of death among U.S. residents aged 15–64 years.

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⁴Death rates are per 100,000 population on the basis of 2021 estimates released by the U.S. Census Bureau on July 27, 2021, available at Methodology (census.gov) and single-race population estimates (cdc.gov). The denominator excluded population estimates from Rhode Island and the District of Columbia.

⁵Age-adjusted death rates (per 100,000 U.S. population) were calculated by applying age-specific death rates to the 2000 U.S. census standard population age distribution; <https://wonder.cdc.gov/wonder/help/mcd.htm#Age-AdjustedRates>.

NVSS, National Vital Statistics System.

Table 2. COVID-19 Decedents and PMR Among Working-Age Adults, by Sex and Industry, 50 U.S. Jurisdictions, 2021

Industry ^d	COVID-19 deaths						
	Males			Females			Total
	n (%)	PMR (95% CI)	n (%)	PMR (95% CI)	n (%)	PMR (95% CI)	
Agriculture, forestry, fishing, and hunting	1,967 (15.3)	0.97 (0.93, 0.82)	267 (16.4)	0.98 (0.87, 1.02)	2,234 (15.4)	0.97 (0.93, 1.01)	
Mining	1,177 (18.8)	1.31 (1.24, 1.39)	44 (16.0)	1.10 (0.82, 1.52)	1,221 (18.7)	1.30 (1.23, 1.39)	
Utilities	1,054 (18.3)	1.32 (1.24, 1.40)	159 (17.5)	1.20 (1.02, 1.40)	1,213 (18.2)	1.30 (1.22, 1.38)	
Construction	11,886 (11.4)	0.79 (0.78, 0.81)	473 (13.4)	0.93 (0.85, 1.02)	12,359 (11.5)	0.80 (0.78, 0.81)	
Manufacturing	10,680 (16.1)	1.15 (1.13, 1.17)	2,720 (15.4)	1.02 (0.98, 1.06)	13,400 (15.9)	1.12 (1.10, 1.14)	
Wholesale trade	1,264 (17.5)	1.23 (1.17, 1.30)	221 (14.9)	0.98 (0.86, 1.12)	1,485 (17.1)	1.19 (1.13, 1.25)	
Retail trade	6,114 (15.7)	1.15 (1.12, 1.18)	3,957 (14.5)	1.01 (0.98, 1.04)	10,071 (15.2)	1.09 (1.07, 1.11)	
Transportation and warehousing	9,027 (18.6)	1.29 (1.26, 1.31)	1,336 (16.3)	1.07 (1.02, 1.13)	10,363 (18.3)	1.25 (1.23, 1.28)	
Information	964 (13.6)	1.00 (0.93, 1.06)	460 (13.5)	0.92 (0.84, 1.01)	1,424 (13.5)	0.97 (0.92, 1.02)	
Finance and insurance	1,281 (15.2)	1.11 (1.05, 1.17)	1,577 (15.4)	1.05 (1.00, 1.10)	2,858 (15.3)	1.07 (1.03, 1.11)	
Real estate and rental and leasing	882 (15.6)	1.07 (1.00, 1.15)	492 (14.0)	0.94 (0.86, 1.02)	1,374 (15.0)	1.02 (0.97, 1.08)	
Professional, scientific, and technical services	2,561 (13.4)	0.96 (0.93, 1.00)	1,255 (11.1)	0.77 (0.73, 0.81)	3,816 (12.5)	0.89 (0.86, 0.92)	
Management of companies and enterprises	63 (19.5)	1.39 (1.08, 1.79)	59 (18.9)	1.29 (0.99, 1.68)	122 (19.2)	1.34 (1.12, 1.60)	
Administrative and support and waste management and remediation services	3,973 (14.1)	0.97 (0.94, 1.00)	1,287 (15.4)	0.96 (0.91, 1.02)	5,260 (14.4)	0.97 (0.94, 0.99)	
Education services	1,909 (17.4)	1.20 (1.15, 1.26)	3,276 (17.4)	1.13 (1.10, 1.17)	5,185 (17.4)	1.16 (1.13, 1.19)	
Healthcare and social assistance	2,694 (14.6)	1.05 (1.01, 1.09)	9,367 (15.8)	1.05 (1.03, 1.07)	12,061 (15.5)	1.05 (1.03, 1.07)	
Arts, entertainment, and recreation	1,416 (12.2)	0.92 (0.87, 0.96)	508 (11.7)	0.82 (0.75, 0.90)	1,924 (12.1)	0.89 (0.85, 0.93)	
Accommodation and food services	3,737 (11.5)	0.85 (0.82, 0.88)	2,625 (11.0)	0.78 (0.75, 0.81)	6,362 (11.3)	0.82 (0.80, 0.84)	
Other services (except public administration)	5,199 (15.2)	1.05 (1.02, 1.08)	2,202 (15.8)	1.04 (1.00, 1.08)	7,401 (15.4)	1.05 (1.02, 1.07)	
Public administration	3,604 (19.9)	1.39 (1.34, 1.43)	1,803 (17.2)	1.11 (1.06, 1.16)	5,407 (18.9)	1.28 (1.24, 1.31)	
All others (military, miscellaneous)	11,098 (10.3)	0.81 (0.79, 0.82)	16,958 (15.1)	1.00 (0.99, 1.02)	28,056 (12.7)	0.91 (0.90, 0.92)	

Data source: NVSS public use multiple cause files 2021; https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm#Mortality_Multiple.

Note: Boldface indicates statistical significance ($p < 0.05$).

The table shows the number and proportion of decedents with COVID-19 (ICD-10 Code U07.1) (death certificate-based ICD-10 diagnosis codes for COVID-19 mortality surveillance, U.S., January–December 2020 [[cdc.gov](https://www.cdc.gov/)]) listed as the underlying cause of death among U.S. residents aged 15–64 years. PMR was defined as the observed number of deaths from COVID-19 in a specified industry divided by the expected number of deaths from COVID-19. The expected number of deaths was the total number of deaths in an industry of interest multiplied by a proportion defined as the number of

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COVID-19 deaths in all industries divided by the total number of deaths in all industries. PMRs were adjusted for 10-year age groups, sex, and race. Working-age U.S. residents are those aged 15–64 years from 50 jurisdictions (excluding the District of Columbia and Rhode Island) with information on their usual occupation.

Industry the decedent worked in during most of his or her life or for the longest time and is the National Health Interview Survey simple industry recode; <https://www.cdc.gov/nchs/data/dvs/Industry-and-Occupation-data-mortality-2020.pdf>.

PMR, proportionate mortality ratio.

Table 3. COVID-19 Decedents and PMR Among Working-Age by Sex and Occupation, 50 U.S. Jurisdictions, 2021

Occupation ^d	COVID-19 deaths								
	Males			Females			Total		
	n (%)	PMR	n (%)	n (%)	PMR	n (%)	PMR		
Management	7,245 (17.8)	1.25 (1.22, 1.28)	2,600 (14.7)	0.99 (0.95, 1.03)	9,845 (16.8)	1.17 (1.14, 1.19)			
Business and financial operations	1,431 (16.0)	1.15 (1.10, 1.22)	1,397 (14.2)	0.95 (0.90, 1.00)	2,828 (15.1)	1.04 (1.00, 1.08)			
Computer and mathematical	1,246 (14.1)	1.05 (0.99, 1.11)	235 (10.2)	0.71 (0.62, 0.81)	1,481 (13.3)	0.97 (0.92, 1.02)			
Architecture and engineering	1,646 (16.1)	1.13 (1.08, 1.19)	107 (9.9)	0.68 (0.56, 0.82)	1,753 (15.5)	1.09 (1.04, 1.14)			
Life, physical, and social science	268 (10.5)	0.79 (0.70, 0.89)	123 (10.3)	0.72 (0.60, 0.86)	391 (10.5)	0.76 (0.69, 0.85)			
Community and social services	1,140 (24.9)	1.68 (1.58, 1.78)	855 (17.2)	1.10 (1.03, 1.18)	1,995 (20.9)	1.37 (1.31, 1.43)			
Legal	194 (10.2)	0.72 (0.63, 0.83)	274 (11.9)	0.81 (0.72, 0.91)	468 (11.1)	0.77 (0.70, 0.84)			
Education, training, and library	829 (16.1)	1.13 (1.06, 1.21)	2,169 (17.0)	1.13 (1.08, 1.18)	2,998 (16.8)	1.13 (1.09, 1.17)			
Arts, design, entertainment, sports, and media	1,155 (11.4)	0.87 (0.82, 0.92)	440 (10.0)	0.72 (0.65, 0.79)	1,595 (11.0)	0.82 (0.78, 0.86)			
Healthcare practitioners and technical	1,030 (15.5)	1.10 (1.04, 1.17)	2,729 (14.7)	1.02 (0.98, 1.05)	3,759 (14.9)	1.04 (1.00, 1.07)			
Healthcare support	366 (14.1)	1.04 (0.94, 1.15)	2,640 (14.8)	0.98 (0.95, 1.02)	3,006 (14.7)	0.99 (0.95, 1.02)			
Protective service	3,022 (20.4)	1.44 (1.39, 1.49)	635 (18.3)	1.18 (1.09, 1.28)	3,657 (20.0)	1.39 (1.34, 1.43)			
Food preparation and serving related	2,577 (10.5)	0.78 (0.75, 0.81)	2,025 (10.7)	0.77 (0.73, 0.80)	4,602 (10.6)	0.77 (0.75, 0.80)			
Building and grounds cleaning and maintenance	3,666 (13.6)	0.91 (0.88, 0.94)	1,610 (15.0)	0.90 (0.86, 0.94)	5,276 (14.0)	0.90 (0.88, 0.93)			
Personal care and service	966 (12.3)	0.89 (0.84, 0.95)	3,026 (16.6)	1.09 (1.05, 1.13)	3,992 (15.3)	1.03 (1.00, 1.06)			
Sales and related	5,345 (16.0)	1.16 (1.13, 1.20)	3,393 (14.0)	0.98 (0.95, 1.01)	8,738 (15.1)	1.08 (1.06, 1.11)			
Office and administrative support	2,981 (15.7)	1.15 (1.11, 1.19)	6,241 (16.6)	1.12 (1.09, 1.15)	9,222 (16.3)	1.13 (1.11, 1.15)			
Farming, fishing, and forestry	1,061 (15.1)	0.90 (0.85, 0.96)	175 (20.9)	1.09 (0.93, 1.26)	1,236 (15.7)	0.93 (0.88, 0.98)			
Construction and extraction	10,618 (11.1)	0.77 (0.76, 0.78)	173 (10.1)	0.70 (0.61, 0.82)	10,791 (11.1)	0.77 (0.75, 0.78)			
Installation, maintenance, and repair	6,014 (15.1)	1.06 (1.04, 1.09)	137 (13.2)	0.92 (0.78, 1.09)	6,151 (15.0)	1.06 (1.03, 1.08)			
Production	6,835 (15.5)	1.09 (1.07, 1.12)	1,829 (15.9)	1.03 (0.98, 1.08)	8,664 (15.6)	1.08 (1.06, 1.10)			
Transportation and material moving	12,545 (16.2)	1.15 (1.13, 1.17)	1,724 (15.7)	1.04 (0.99, 1.09)	14,269 (16.2)	1.13 (1.12, 1.15)			
All others (military, miscellaneous, housewives)	10,370 (10.4)	0.82 (0.80, 0.83)	16,509 (15.1)	1.00 (0.99, 1.02)	26,879 (12.8)	0.92 (0.91, 0.93)			

Data source: NVSS public use mortality multiple cause file 2021; https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm#Mortality_Multiple.

Note: Boldface indicates statistical significance ($p < 0.05$).

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Significantly elevated PMRs are shown. The table shows the number and proportion of decedents with COVID-19 (ICD-10 Code U07.1) (death certificate-based ICD-10 diagnosis codes for COVID-19 mortality surveillance, U.S., January–December 2020 [[cdc.gov](https://www.cdc.gov)]) listed as the underlying cause of death. *PMR* was defined as the observed number of deaths from COVID-19 in a specified industry divided by the expected number of deaths from COVID-19. The expected number of deaths was the total number of deaths in an industry of interest multiplied by a proportion defined as the number of COVID-19 deaths in all industries divided by the total number of deaths in all industries. PMRs were adjusted for 10-year age groups, sex, and race. Working-age U.S. residents are those aged 15–64 years from 49 jurisdictions (excluding the District of Columbia and Rhode Island) with information on their usual occupation information.

^aOccupations the decedent worked in during most of his or her life or for the longest time and is National Health Interview Survey simple occupation recode; <https://www.cdc.gov/nchs/data/dvs/Industry-and-Occupation-data-mortality-2020.pdf>.

PMR, proportional mortality ratio.