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COVID-19 Mortality by Usual Occupation and Industry: 46 States and New York City, United States, 2020

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Abstract

Objectives—This report describes COVID-19 mortality in 2020 among U.S. residents in 46 states and New York City by usual occupation and industry.

Methods—Frequencies, death rates, and proportionate mortality ratios (PMRs) are presented using data from the 2020 National Vital Statistics System mortality file. Data were restricted to decedents aged 15–64 (working age) with usual occupations and industries in the paid, civilian workforce. Age-standardized COVID-19 death rates were estimated for each usual occupation and industry group overall, and age-adjusted COVID-19 PMRs were estimated for each usual occupation and industry group overall and within each sex, race and Hispanic-origin, and region of residence group.

Results—COVID-19 death rates and PMRs showed differences across usual occupations and industries in 2020. Workers in protective service occupations (60.3 per 100,000 workers, 95% confidence interval: 53.5–67.2) and accommodation and food services industries (55.0, 51.1–58.9) experienced the highest death rates. The highest PMRs were observed among decedents in community and social services occupations (158.5, 151.4–165.7) and in transportation and warehousing (119.3, 116.3–122.2), healthcare and social assistance (118.7, 116.3–121.1), and administrative, support, and waste services (118.3, 114.5–122.1) industries. Variability in COVID-19 PMRs by usual occupation and industry group was also observed within demographic subgroups.

Conclusions—COVID-19 mortality in 2020 varied by usual occupation and industry overall and within demographic subgroups.

Keywords: worker health • SARS-CoV-2 • death rates • proportionate mortality ratios • census codes • National Vital Statistics System

Introduction

The World Health Organization (WHO) declared the 2019 novel coronavirus, or COVID-19, a public health emergency of international concern on January 30, 2020 (1). An *International Classification of Diseases, 10th Revision* (ICD–10) emergency code (U07.1) was immediately created to consistently document this new coronavirus (2). The COVID-19 pandemic has since impacted all U.S. residents, with some populations disproportionately affected (3).

Work is a core social determinant of health and working conditions, and job tasks influence transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19 (4). This report describes COVID-19 mortality in 2020 by usual occupation and industry. COVID-19 death rates and proportionate mortality ratios (PMRs) are estimated for each occupation and industry group overall. COVID-19 PMRs are also estimated for each occupation and industry group within each sex, race and Hispanic-origin, and region of residence group.

Data Sources

Mortality data are from the National Center for Health Statistics' National Vital Statistics System (NVSS) 2020 mortality file. Data on usual occupation and industry are available for 91% of decedents aged 15 and over in the 2020 NVSS mortality file and are reported by 46 states and New York City. Results are only representative of decedents in these 47 jurisdictions. Occupation and industry data were also missing for substantial portions of decedents (6%–11%) in two participating states (5). See the Technical Notes for more information on participating jurisdictions and data availability.

The U.S. Standard Certificate of Death (6) records usual occupation and industry, or the occupation and industry in which the decedent spent most of their working life. Occupation is the

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics
National Vital Statistics System

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type of work that a person performs, or their job (such as teacher or cashier), while industry is the type of business a person works in (such as an elementary school or grocery store). Usual occupation or industry may differ from current occupation or industry at death. However, usual occupation has been shown to be a reasonable surrogate for current occupation among currently or recently employed workers (7). Occupation and industry narratives provided on death certificates were coded to standardized individual U.S. Census Bureau occupation and industry codes through a collaboration with the National Institute for Occupational Safety and Health (NIOSH) (5). Census codes were then aggregated into broad groups using the National Health Interview Survey (NHIS) simple occupation and industry recodes (8) to minimize suppression of results due to small populations. This aggregation may smooth over contrasting results in some component occupations and industries. See Technical Notes for more information on occupation and industry coding.

Cause-of-death statistics presented in this report are classified using ICD–10 codes. The underlying cause of death, which is the disease or condition responsible for initiating the chain of events leading to death, was applied for all analyses (9). Death from COVID-19 was defined as an underlying cause of death coded as U07.1 (2).

Population estimates from the April 2020 Current Population Survey (CPS) were applied as denominators for the estimation of death rates. CPS estimates are weighted to represent the U.S. civilian noninstitutional population aged 16–64 in the 47 participating jurisdictions only (10). See Technical Notes for more information on the use of CPS estimates in the calculation of death rates.

Statistical Methods

Mortality measures

COVID-19 death rates and PMRs were estimated for working-age decedents in each occupation and industry group. Death rates may be applied to compare the number of deaths from COVID-19 per 100,000 workers between occupation and industry groups in a standardized way. In contrast, PMRs evaluate relative COVID-19 mortality using a ratio of two proportions, estimated as the proportion of deaths from COVID-19 within each group of workers (numerator) compared with the proportion of deaths from COVID-19 among all workers (denominator), multiplied by 100. For example, the unadjusted COVID-19 PMR among decedents in healthcare support occupations is estimated as:

$$\left(\frac{\dfrac{\text{COVID-19 deaths among healthcare support workers}}{\text{Total deaths among healthcare support workers}}}{\dfrac{\text{COVID-19 deaths among all workers}}{\text{Total deaths among all workers}}} \right) \cdot 100$$

In this report, a PMR over 100 indicates that COVID-19 deaths in that occupation (or industry) group or subgroup comprise a greater proportion of deaths among that set of decedents than across decedents in all occupations (or industries) combined. PMRs are mutually dependent between causes of death because the proportions of deaths from all causes within a worker group must sum to 100 (11).

Death rates and PMRs frequently display similar patterns, but results may diverge within working-age populations that experience particularly high or low overall mortality. For example, the proportion of deaths attributed to COVID-19 (and consequently the COVID-19 PMR) may be lower among occupation groups with higher underlying mortality rates and higher baseline prevalence of competing causes of death. Higher income is associated with longer life expectancy (12). If COVID-19 death rates were equal within all occupation and industry groups, elevated COVID-19 PMRs within high-income occupations and industries would be expected due to lower baseline prevalence of competing causes of death within these working-age populations. Death rates identify worker populations with the highest risks of death from COVID-19, regardless of deaths from all causes, while PMRs identify worker populations with the highest proportions of deaths from COVID-19.

Death rates

Data were restricted to U.S. resident decedents aged 16–64 in the paid, civilian workforce. Decedents aged 15 were excluded because they are not represented in CPS workforce population denominator estimates (10). Decedents with unpaid or military occupations or industries were also excluded from estimation of COVID-19 death rates by occupation or industry because appropriate population estimates are not available from CPS (10). People with unpaid occupations and industries include homemakers, people with disabilities preventing work, people who are incarcerated, students, and people for whom no or unusable information was entered (5).

Age-standardized COVID-19 death rates were computed based on age-specific death rates in each occupation and industry group and the 2000 U.S. standard population aged 15–64 (see Technical Notes) as deaths per 100,000 workers. Direct age-standardization was performed using 10-year categories, excluding age 15 (16–24, 25–34, 35–44, 45–54, and 55–64).

CPS is a population-based survey, and occupation and industry denominators are estimates of worker population size (10). Sampling variance data are not available from CPS for the specific study populations. Parameters from a proxy series were applied to estimate approximate population denominator standard errors that account for sampling variance under the CPS design effect (13). No hypothesis tests were performed to compare death rates between worker populations given the large number of comparisons and the uncertainty in denominator sampling variance estimates, and a higher rate within one worker population compared with another does not denote a statistically significant difference. Death rates were not estimated for occupation and industry groups within demographic and geographic subpopulations because subpopulation denominator estimates may be unstable. See Technical Notes for more information on the estimation of age-standardized COVID-19 death rates and confidence intervals (CIs).

PMRs

Data were restricted to U.S. resident decedents aged 15–64 in the paid, civilian workforce. Decedents with unpaid or military occupations or industries were excluded (5) to minimize any healthy worker effect, or bias due to differences in underlying health among workers and nonworkers (14), in comparative analyses.

COVID-19 PMRs were estimated for each occupation and industry group overall in reference to the proportion of deaths from COVID-19 among all decedents with paid, civilian usual occupations or industries. PMRs were internally adjusted to the age distributions of U.S. resident decedents aged 15–64 who were identified in usual occupations and industries in the paid, civilian workforce (5). Age adjustment was performed using 10-year age groups (15–24, 25–34, 35–44, 45–54, and 55–64).

COVID-19 PMRs were also estimated by occupation and industry group within each sex, race and Hispanic-origin group, U.S. Census Bureau region, and U.S. Department of Health and Human Services (HHS) region in stratified analyses. PMRs for each occupation and industry group in each census and HHS region were estimated among the subpopulation of decedents for whom death occurred in their state of residence and who lived in a participating jurisdiction because occupation and industry data were not available for deaths that occurred in some jurisdictions. This exclusion was a conservative approach to address missingness among decedents who lived in participating jurisdictions but who were issued death certificates by nonparticipating jurisdictions, applying the exclusion consistently to decedents residing in all participating jurisdictions who died outside of their state of residence. COVID-19 PMRs within each demographic and geographic group were internally adjusted to the separate age distributions of U.S. resident decedents in that demographic or geographic group aged 15–64 with paid, civilian usual occupations or industries using the same 10-year age categories.

Occupation and industry group-level PMRs are described in comparison to the total population for overall estimates or in comparison to the demographic or geographic subpopulation for stratified estimates against a referent PMR value of 100.0 in each population. PMRs are considered elevated in this report if the lower bound of the 95% CI is over 100.0. No hypothesis tests were performed to compare PMRs between worker populations, given the large number of comparisons, and a higher PMR within one worker population compared with another does not denote a statistically significant difference. COVID-19 PMRs based on fewer than 20 deaths were suppressed. See Technical Notes for more information on the estimation of age-adjusted PMRs and CIs.

Race and Hispanic origin were classified according to the 1997 standards (15) and differ from bridged-race groups used in National Center for Health Statistics reports before 2018. Some race and Hispanic-origin groups were combined for analysis. Groups presented are Hispanic, non-Hispanic American Indian or Alaska Native (AIAN), non-Hispanic Asian, non-Hispanic Black, and non-Hispanic White. PMRs for each occupation and industry group among non-Hispanic Native Hawaiian or Other Pacific Islander (NHOPI) and non-Hispanic multiple-race workers are not presented due to small counts. See Technical Notes for more information on the classification of race and Hispanic origin.

Results

COVID-19 death rates by usual occupation and industry group

COVID-19 death rates varied across usual occupation groups in 2020 (Figure 1, Table 1). Workers in 10 usual occupation groups, including protective service (60.3 deaths per 100,000 workers, 95% CI: 53.5–67.2); food preparation and serving related (57.5, 53.0–61.9); construction and extraction (57.3, 53.7–61.0); transportation and material moving (56.0, 53.1–58.8); farming, fishing, and forestry (54.8, 45.7–63.9); personal care and service (51.2, 46.0–56.4); production (44.8, 42.0–47.6); building and grounds cleaning and maintenance (43.7, 40.6–46.8); installation, maintenance, and repair (36.5, 33.5–39.5); and community and social services (34.5, 30.7–38.4), experienced age-standardized COVID-19 death rates with larger absolute values and confidence intervals compared with the COVID-19 death rate among workers in all occupations combined (28.6, 28.2–29.0).

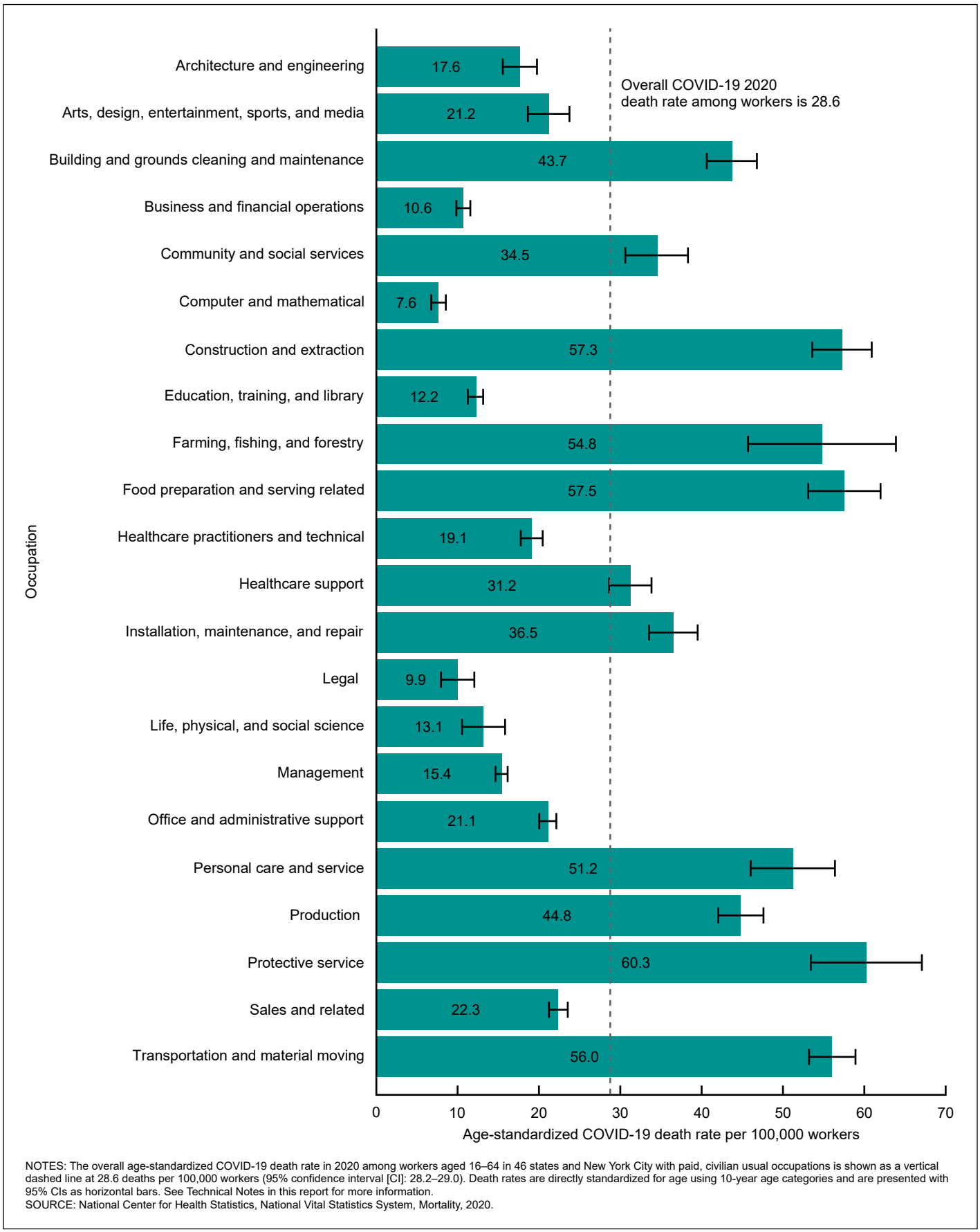
COVID-19 death rates also differed by usual industry group in 2020 (Figure 2, Table 2). Workers in eight usual industry groups, including accommodation and food services (55.0 deaths per 100,000 workers, 95% CI: 51.1–58.9); transportation and warehousing (49.6, 46.6–52.6); construction (42.3, 40.1–44.5); mining (41.5, 33.0–49.9); other services (except public administration) (41.0, 38.2–43.8); agriculture, forestry, fishing, and hunting (40.7, 36.0–45.4); management, administrative, and waste services (38.9, 36.1–41.6); and manufacturing (30.2, 28.8–31.5), experienced age-standardized COVID-19 death rates with larger absolute values and confidence intervals compared with the COVID-19 death rate among workers in all industries combined (28.3, 27.9–28.7).

COVID-19 PMRs by usual occupation and industry group

COVID-19 PMRs—the proportion of deaths from COVID-19 within each group compared with the proportion of deaths from COVID-19 among all workers—varied across usual occupation groups in 2020 (Figure 3, Table 3). Decedents in 10 usual occupation groups, including community and social services (PMR: 158.5, 95% CI: 151.4–165.7); protective service (142.6, 137.4–147.9); farming, fishing, and forestry (132.8, 123.1–143.1); building and grounds cleaning and maintenance (120.1, 116.5–123.7); healthcare support (118.0, 113.0–123.0); transportation and material moving (117.7, 115.4–120.0); production (110.3, 107.4–113.2); healthcare practitioners and technical (107.5, 103.3–111.7); personal care and service (105.7, 101.2–110.2); and food preparation and serving related (105.1, 101.6–108.5), showed age-adjusted COVID-19 PMRs with the lower bound of the 95% CI over 100.0, or the referent PMR among decedents in all occupations combined.

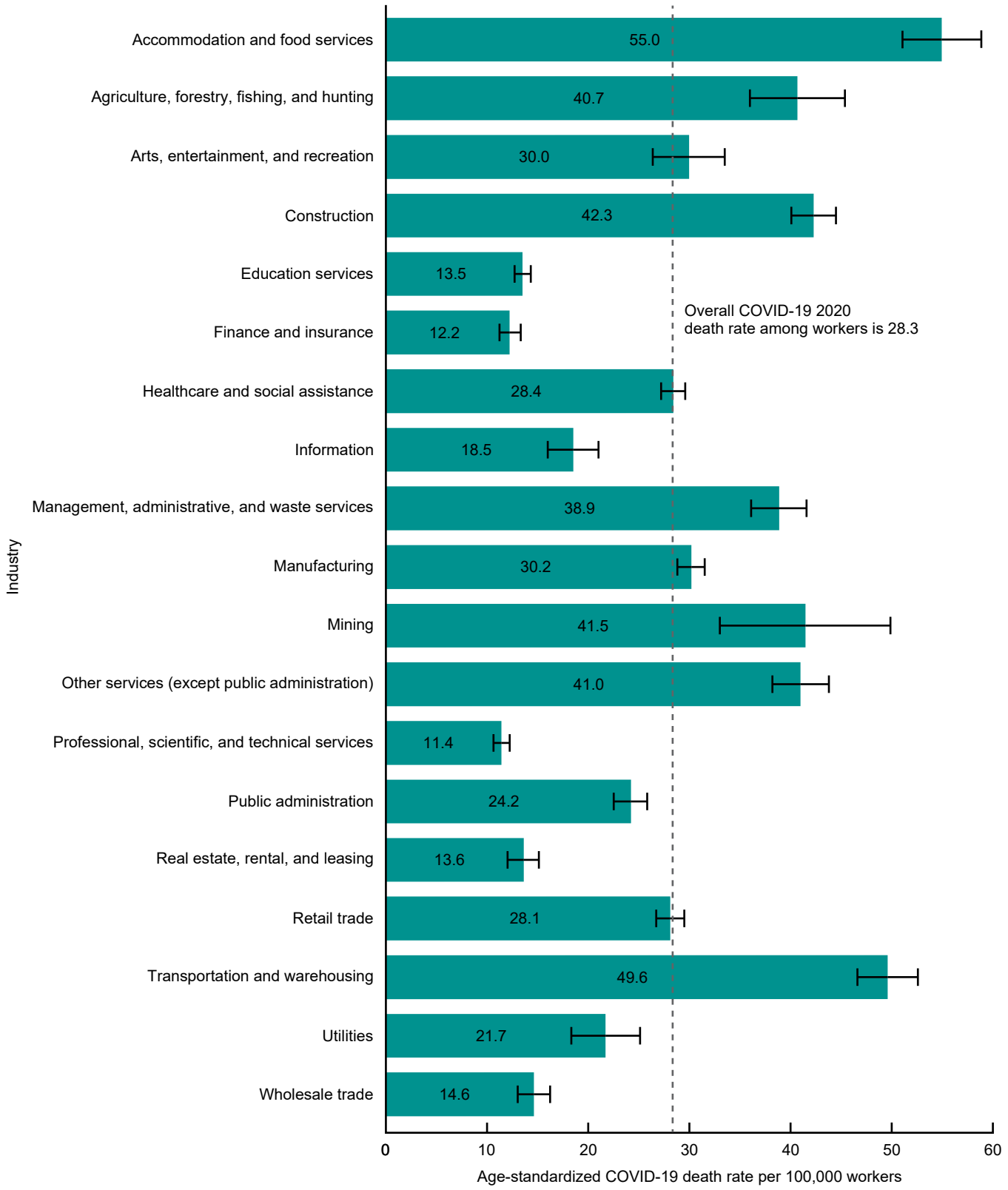
COVID-19 PMRs also differed by usual industry group

Figure 1. COVID-19 death rates among U.S. residents aged 16–64, by usual occupation group: 46 states and New York City, 2020



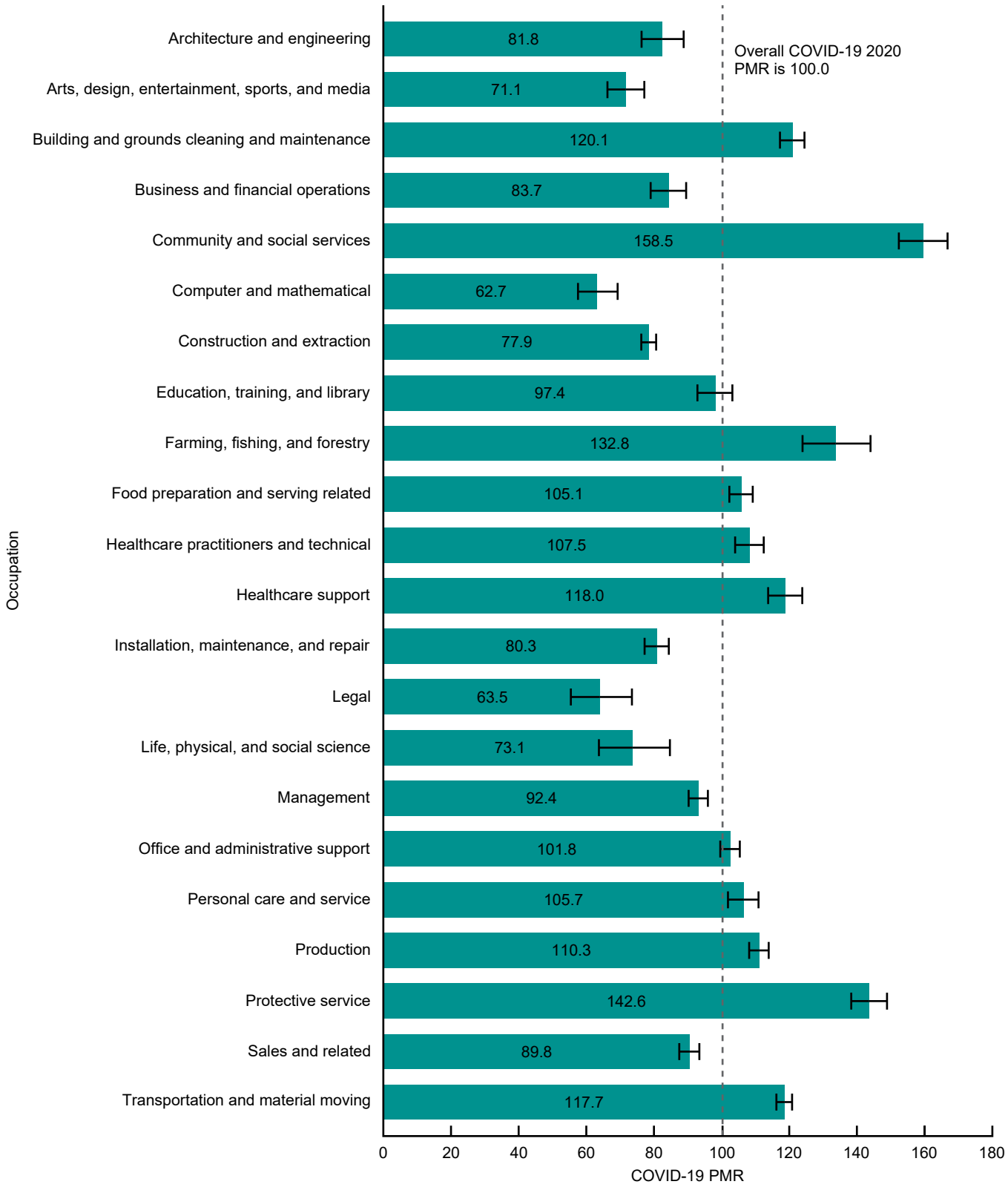
NOTES: The overall age-standardized COVID-19 death rate in 2020 among workers aged 16–64 in 46 states and New York City with paid, civilian usual occupations is shown as a vertical dashed line at 28.6 deaths per 100,000 workers (95% confidence interval [CI]: 28.2–29.0). Death rates are directly standardized for age using 10-year age categories and are presented with 95% CIs as horizontal bars. See Technical Notes in this report for more information.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Figure 2. COVID-19 death rates among U.S. residents aged 16–64, by usual industry group: 46 states and New York City, 2020



NOTES: The overall age-standardized COVID-19 death rate in 2020 among workers aged 16–64 in 46 states and New York City with paid, civilian usual industries is shown as a vertical dashed line at 28.3 deaths per 100,000 workers (95% confidence interval [CI]: 27.9–28.7). Death rates are directly standardized for age using 10-year age categories and are presented with 95% CIs as horizontal bars. The National Health Interview Survey's administrative support, and waste services and management of companies and enterprises industries were combined to align with the Current Population Survey's management, administrative, and waste services industry category. See Technical Notes in this report for more information.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Figure 3. COVID-19 proportionate mortality ratios among decedents aged 15–64, by usual occupation group: 46 states and New York City, 2020



NOTES: PMR is proportionate mortality ratio. Overall relative COVID-19 mortality among 2020 decedents aged 15–64 in 46 states and New York City with paid, civilian usual occupations, estimated as a PMR, is shown as a vertical dashed line at 100.0. PMR 95% confidence intervals were estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19 and are shown as horizontal bars. PMRs are internally adjusted for age using 10-year age categories. See Technical Notes in this report for more information.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

in 2020 (Figure 4, Table 4). Decedents in eight usual industry groups, including transportation and warehousing (PMR: 119.3, 95% CI: 116.3–122.2); healthcare and social assistance (118.7, 116.3–121.1); administrative, support, and waste services (118.3, 114.5–122.1); public administration (115.0, 111.0–119.0); agriculture, forestry, fishing, and hunting (114.5, 108.6–120.4); wholesale trade (109.8, 101.3–118.9); accommodation and food services (103.7, 100.7–106.8); and manufacturing (103.4, 101.1–105.7), showed age-adjusted COVID-19 PMRs with the lower bound of the 95% CI more than 100.0, or the referent PMR among decedents in all industries combined.

COVID-19 PMRs by usual occupation and industry group and sex

COVID-19 PMRs by usual occupation and industry groups varied among male and female decedents. The highest PMRs among male decedents were observed among those in community and social services occupations (PMR: 194.7, 95% CI: 180.3–209.9) (Table 5) and in healthcare and social assistance industries (140.8, 135.9–145.6) (Table 6). The highest PMRs among female decedents were observed among those in farming, fishing, and forestry occupations (196.1, 160.3–237.7) and in agriculture, forestry, fishing, and hunting (123.1, 103.0–145.9) and healthcare and social assistance (122.6, 119.9–125.2) industries.

COVID-19 PMRs showed consistent effect directions for both male and female decedents in many occupation and industry groups. However, several worker groups experienced PMRs with 95% CIs over 100.0 among male decedents and PMRs with 95% CIs under 100.0 among female decedents in comparison to all male and female decedents, including: food preparation and serving related occupations (PMR: 125.4, 95% CI: 120.8–130.0 among male decedents and 81.4, 76.1–86.9 among female decedents), retail trade industries (105.5, 102.1–109.0 among male decedents and 84.3, 79.8–88.7 among female decedents), and accommodation and food services industries (124.0, 120.0–128.0 among male decedents and 77.6, 72.8–82.4 among female decedents).

COVID-19 PMRs by usual occupation and industry group and race and Hispanic origin

COVID-19 PMRs across usual occupation groups also varied within race and Hispanic-origin groups. The highest PMR among Hispanic decedents was observed among those in production occupations (PMR: 124.6, 95% CI: 120.5–128.7) (Figure 5, Table 7). The highest PMRs among non-Hispanic AIAN (160.4, 104.8–235.0) and non-Hispanic White (185.4, 165.9–206.5) decedents were observed among those in community and social services occupations, while the highest PMRs among non-Hispanic Asian (166.7, 124.9–218.1) and non-Hispanic Black (152.6, 141.7–164.0) decedents were observed among those in protective service occupations.

Similar variation in COVID-19 PMRs across usual industry groups was identified within race and Hispanic-origin groups. The highest PMR among Hispanic decedents was observed among those in manufacturing industries (122.7, 119.1–126.4) (Figure 6, Table 8). The highest PMRs among non-Hispanic AIAN (141.7, 119.8–166.6) and non-Hispanic Asian (142.3, 128.5–157.1) decedents were observed among those in healthcare and social assistance industries, while the highest PMRs among non-Hispanic Black (132.6, 124.2–141.6) and non-Hispanic White (136.7, 128.0–145.9) decedents were observed among those in public administration industries.

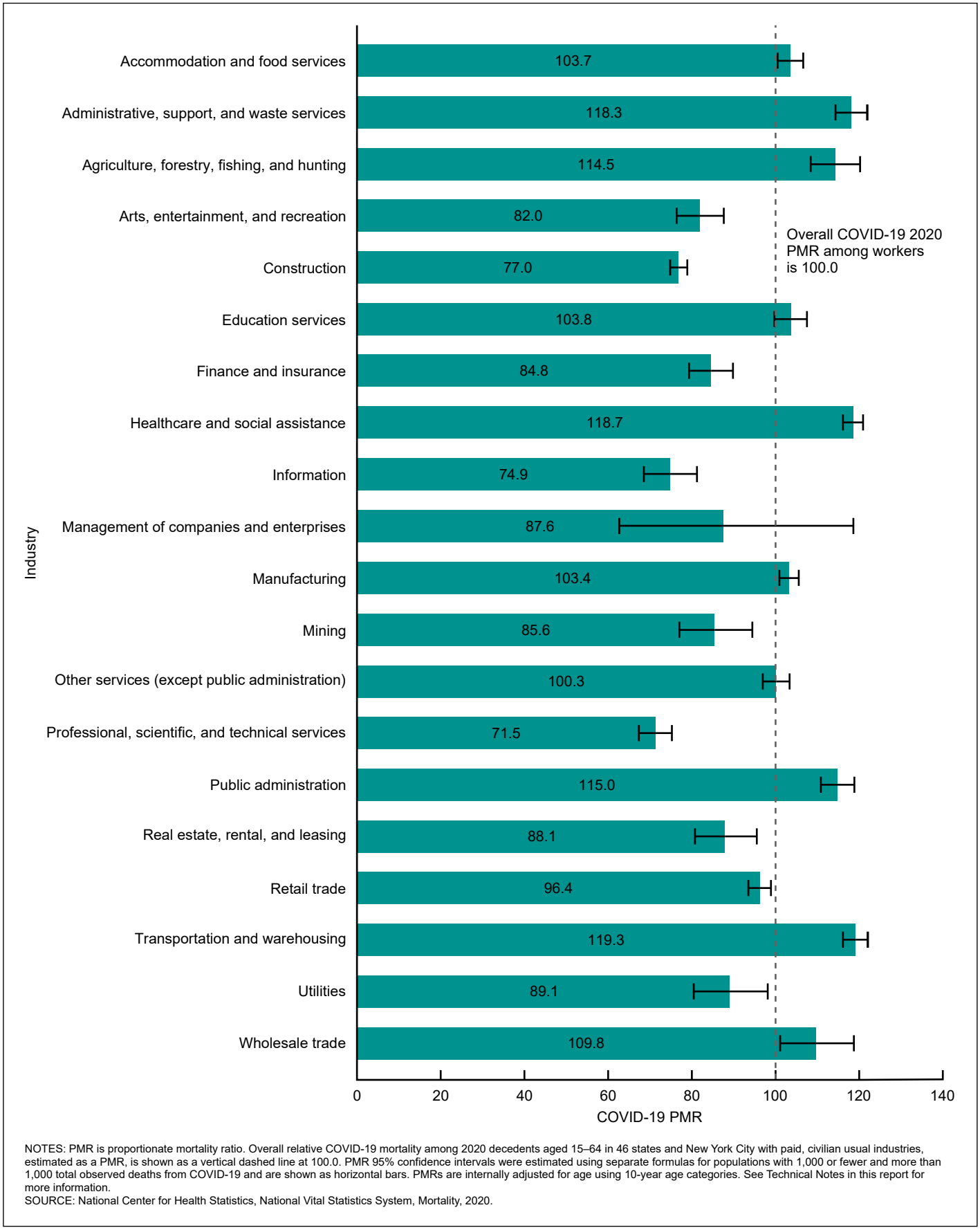
Although many occupation and industry groups showed consistent patterns in COVID-19 PMRs within each race and Hispanic-origin group, several worker populations experienced different effect directions or magnitudes within selected race and Hispanic-origin groups. For example, Hispanic decedents in food preparation and serving related, building and grounds cleaning and maintenance, and production occupations and accommodation and food services and manufacturing industries experienced elevated COVID-19 PMRs. However, decedents in these occupation and industry groups did not show elevated COVID-19 PMRs within any other race and Hispanic-origin population.

COVID-19 PMRs by usual occupation and industry group and region of residence

Occupation and industry groups with the highest COVID-19 PMRs differed by region (Tables 9 and 10). The highest PMRs in the Midwest and South were experienced by decedents in community and social services occupations (PMR: 164.3, 95% CI: 140.1–191.4 and 194.6, 177.0–213.3, respectively) and public administration industries (129.6, 116.5–143.8 and 129.2, 122.8–135.5, respectively). The highest PMRs in the Northeast were experienced by decedents in protective service occupations (149.3, 136.7–162.8) and transportation and warehousing industries (143.4, 137.4–149.3). The highest PMRs in the West were experienced by decedents in farming, fishing, and forestry occupations (179.6, 161.7–199.0) and agriculture, forestry, fishing, and hunting industries (153.3, 140.0–167.4).

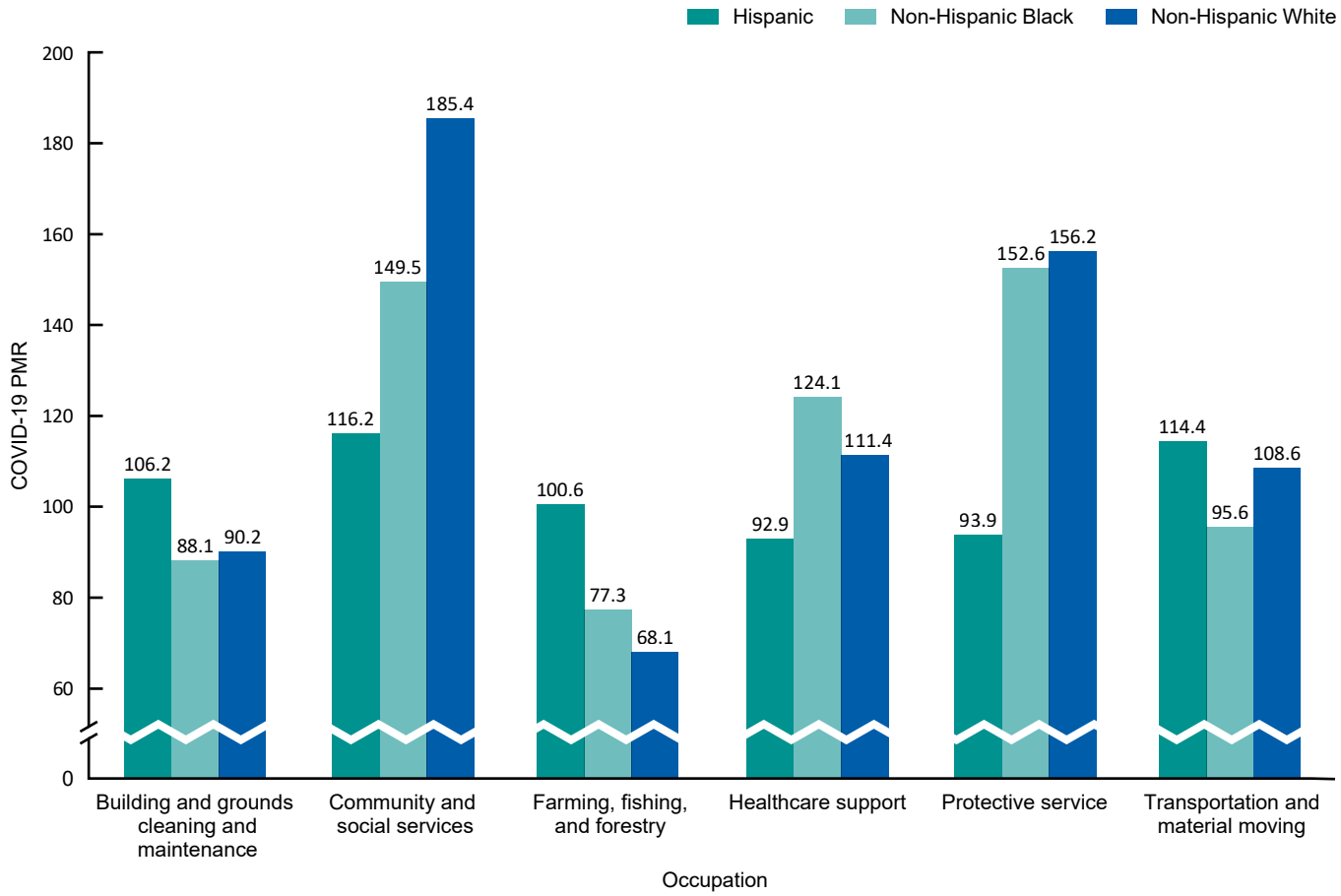
Some occupation and industry groups showed consistently elevated COVID-19 PMRs within all geographic regions. However, several occupation and industry groups experienced different patterns in COVID-19 PMRs within selected regions. For example, decedents in education, training, and library occupations (PMR: 112.2, 95% CI: 102.9–122.2) and education services industries (122.6, 115.1–130.5) experienced elevated COVID-19 PMRs in the South. In contrast, decedents in the Northeast and West in these occupation and industry groups experienced COVID-19 PMRs with 95% CIs under 100.0. Among more detailed HHS regions, COVID-19 PMRs for decedents in education, training, and library occupations (123.3, 108.3–139.8) were elevated in Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, South Carolina, and Tennessee) only, while COVID-19 PMRs for decedents in education services industries were elevated in Region 4 (133.0, 121.0–146.0) and Region 6 (112.9, 103.1–123.5) (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas) only (Tables 11 and 12).

Figure 4. COVID-19 proportionate mortality ratios among decedents aged 15–64, by usual industry group: 46 states and New York City, 2020



NOTES: PMR is proportionate mortality ratio. Overall relative COVID-19 mortality among 2020 decedents aged 15–64 in 46 states and New York City with paid, civilian usual industries, estimated as a PMR, is shown as a vertical dashed line at 100.0. PMR 95% confidence intervals were estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19 and are shown as horizontal bars. PMRs are internally adjusted for age using 10-year age categories. See Technical Notes in this report for more information.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Figure 5. The six usual occupation groups with the highest overall COVID-19 proportionate mortality ratios among decedents aged 15–64, by race and Hispanic origin: 46 states and New York City, 2020



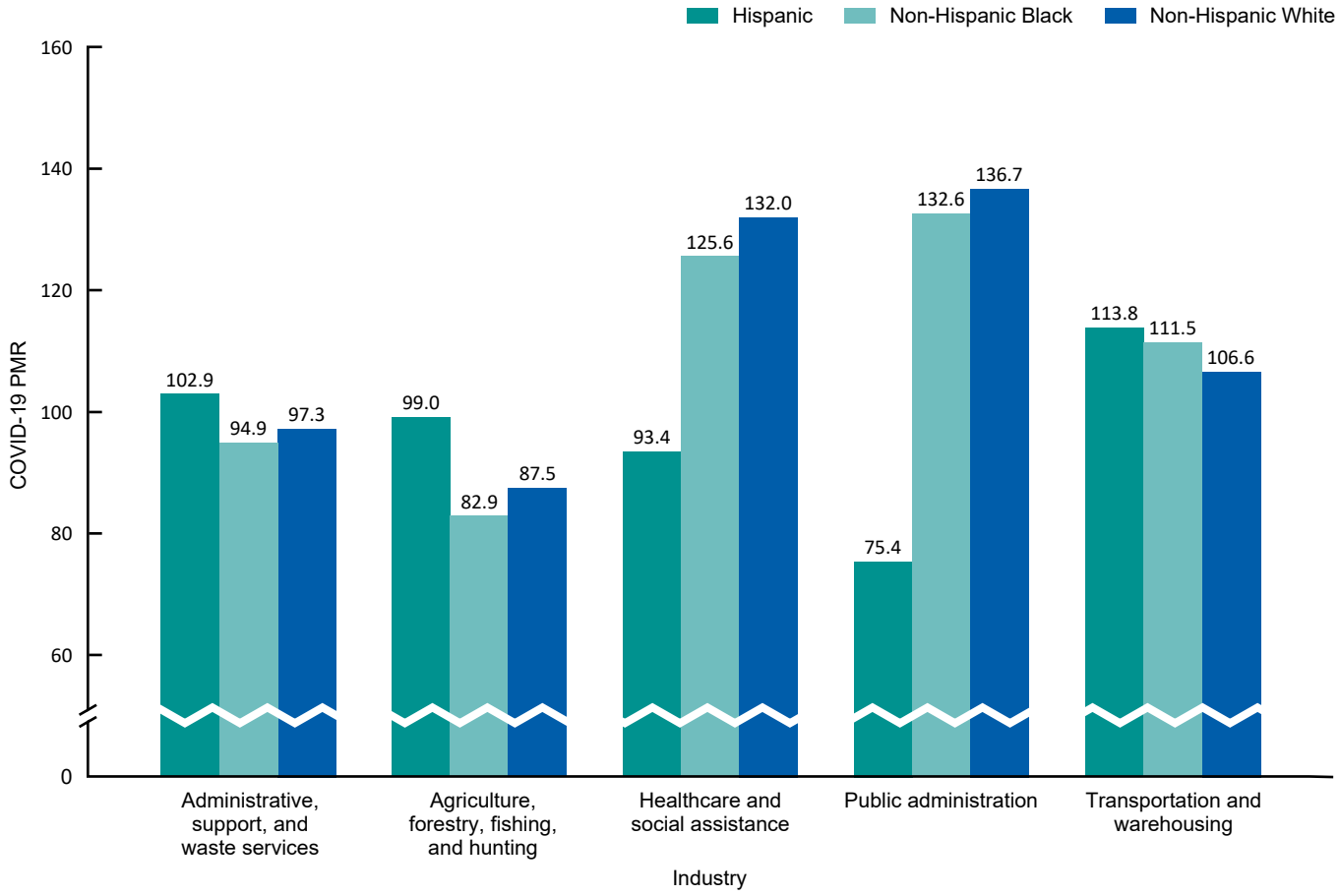
NOTES: PMR is proportionate mortality ratio. Frequencies and PMRs with 95% confidence intervals for all usual occupation groups and additional race and Hispanic origin populations are available in Table 7 in this report. PMRs are internally adjusted to the separate age distributions of U.S. resident decedents in each race and Hispanic origin group aged 15–64 with paid, civilian usual occupations using 10-year age categories. See Technical Notes in this report for more information.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Discussion

COVID-19 death rates and PMRs varied across usual occupation and industry groups in 2020. These findings are consistent with previous analyses that highlighted wide-ranging differences in mortality by usual occupation and industry in selected states since 1985 (16) and with international and state-level analyses assessing COVID-19 mortality (17–21). Many of the occupation groups that displayed elevated COVID-19 death rates and PMRs in this report align with occupation groups identified in other analyses of COVID-19 mortality. However, this report describes U.S. COVID-19 mortality by both occupation and industry for all of 2020. Many occupation and industry groups showed consistent patterns in COVID-19 PMRs within all demographic groups, while others showed elevated COVID-19 PMRs within selected demographic groups only.

Workers may experience differential SARS-CoV-2 exposure opportunities under varying work characteristics. Many occupations and industries with elevated COVID-19 death rates and PMRs are part of the essential critical infrastructure workforce, which includes the healthcare, critical manufacturing, and food and agriculture sectors, among others (22). These workers were most often required to work in person throughout stay-at-home orders in 2020 (22), and job tasks and working environments associated with many of these occupations and industries may increase SARS-CoV-2 exposure risk (23–25). Essential worker status in 2020 was largely determined by industry (22), while ability to work remotely, proximity to others, exposure to infectious agents, and interaction with the public while at work are dependent on both occupation and industry (22–25). For example, workers in protective service occupations and accommodation and food services industries experienced elevated COVID-19 death rates and PMRs compared with workers in all occupations and industries combined. Protective service occupations include police officers, firefighters, correctional officers, security guards, etc., while accommodation and food services industries include hotels, restaurants, bars, etc. Many workers in protective service occupations and accommodation and food services industries were considered essential workers (22), were unable to work remotely (24), and were required to be in close proximity to members of the public and coworkers while at work (23,25).

Figure 6. The five usual industry groups with the highest overall COVID-19 proportionate mortality ratios among decedents aged 15–64, by race and Hispanic origin: 46 states and New York City, 2020



NOTES: PMR is proportionate mortality ratio. Frequencies and PMRs with 95% confidence intervals for all usual industry groups and additional race and Hispanic origin populations are available in Table 8 in this report. PMRs are internally adjusted to the separate age distributions of U.S. resident decedents in each race and Hispanic origin group aged 15–64 with paid, civilian usual industries using 10-year age categories. See Technical Notes in this report for more information.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Most occupation and industry groups with elevated COVID-19 death rates compared with all occupations and industries combined also displayed elevated COVID-19 PMRs. However, some worker groups showed differences in effect direction or magnitude across the two measures, likely due to differences in baseline mortality that impact PMRs. One exception occurred among workers in healthcare practitioner and technical occupations, who experienced an elevated COVID-19 PMR but a lower COVID-19 death rate than workers in all occupations combined. Decedents in community and social services occupations also experienced a strongly elevated COVID-19 PMR, but only a slightly higher COVID-19 death rate than workers in all occupations combined. Community and social services occupations include social workers, community health workers, clergy, etc. These findings may reflect comparatively low mortality from causes other than COVID-19 among working-age people in these occupations, allowing deaths from COVID-19 to comprise large portions of all deaths. In contrast, workers in construction and extraction and installation, maintenance, and repair occupations experienced elevated COVID-19 death rates compared with workers in all occupations combined but showed COVID-19 PMRs below the PMR among decedents in all occupations combined. Decedents in food preparation and serving related occupations and accommodation and food services industries also experienced strongly elevated COVID-19 death rates but showed COVID-19 PMRs only slightly greater than the PMR among all decedents combined. High COVID-19 death rates and comparatively lower COVID-19 PMRs may reflect high mortality from other causes among these worker populations, reducing the proportions of deaths from COVID-19. These results are consistent with the nature of PMRs, which vary according to the distribution of causes of deaths within a given population and provide insight only into differences in the proportion of deaths from the cause of interest, rather than absolute risk (11).

Many of the occupation and industry groups with elevated overall COVID-19 PMRs showed elevated PMRs within all or most demographic groups, demonstrating consistent associations between work and COVID-19 mortality. However, numerous reports have identified elevated national COVID-19 case and death rates among some demographic populations (26–28) and some occupation and industry groups displayed differences in

PMR direction or magnitude in stratified analyses. For example, particularly elevated COVID-19 PMRs were observed among Hispanic decedents in production occupations and manufacturing industries, and among female decedents in farming, fishing, and forestry occupations. These COVID-19 PMRs among Hispanic decedents may reflect both lower mortality from other causes of death (29) and greater overall COVID-19 mortality, as reported elsewhere (27), among Hispanic working-age populations. These PMRs may also reflect the concentration of Hispanic workers in the highest risk occupations and industries within some occupation and industry groups via occupational segregation (30,31). Intersectional demographic composition of some worker groups may also affect COVID-19 PMR estimates; female workers in farming, fishing, and forestry occupations more commonly identify as Hispanic than male workers (32), which may contribute to the particularly elevated COVID-19 PMR observed among female decedents in this occupation group.

Differences in COVID-19 PMRs by occupation and industry group within each geographic region may partially reflect spatiotemporal SARS-CoV-2 transmission dynamics in 2020. For example, COVID-19 PMRs among decedents in food preparation and serving related occupations and accommodation and food services industries were elevated in the Northeast and West only. These findings are consistent with more widespread transmission of SARS-CoV-2 among public-facing workers in some regions before the recommendation, availability, and adoption of COVID-19 risk mitigation strategies and the development of improved COVID-19 treatments (33). Geographic differences may also partially result from the demographic composition of each occupation and industry group in each region.

Overall death rates and PMRs were standardized or adjusted for age but were not adjusted for other factors that may impact likelihood of SARS-CoV-2 infection or COVID-19 mortality, including sex, race, Hispanic origin, or geography. For example, SARS-CoV-2 infection fatality ratios at all ages differ substantially by sex (34). A greater proportion of male patients than female patients infected with SARS-CoV-2 die from COVID-19 (34), and occupations and industries with greater proportions of male workers may therefore show higher overall COVID-19 death rates and PMRs than those with greater proportions of female workers. Stratified PMRs among demographic subpopulations may offer insights into the impact of demographic composition on overall PMRs in each occupation and industry group. This analysis only evaluates COVID-19 PMRs by occupation and industry within demographic groups, and PMRs cannot be compared between demographic groups to directly assess intersectional effects of work and demographic characteristics. Within stratified PMR analyses addressing demographic factors individually, additional characteristics not captured on death certificates may also vary differentially across occupation and industry groups and impact observed COVID-19 mortality. Such characteristics include personal and employer use of COVID-19 risk mitigation strategies, household members' employment, prevalence of pre-existing conditions, socioeconomic status, and housing and commuting density.

Additional research could further characterize mortality within specific occupation and industry groups or individual occupations and industries to identify effects of specific working conditions on death from COVID-19. As one example, workers in accommodation and food services industries and food preparation and serving related occupations experienced elevated COVID-19 death rates and PMRs. Work-related factors, such as hot and crowded restaurant kitchen environments that could reduce mask use and limit the ability to maintain safe distances, may heighten SARS-CoV-2 transmission (35). Occupational segregation of workers within accommodation and food services industries and food preparation and serving related occupations by demographic characteristics (30,36) may also result in increased SARS-CoV-2 exposure risk among some worker populations. For instance, PMRs among male and female workers in accommodation and food services industries and food preparation and serving related occupations showed opposite effect directions and elevated COVID-19 PMRs among male workers only, which may reflect differences in job tasks and employment disruptions during the pandemic by sex. Some occupations in the food preparation and serving related occupation group are predominantly staffed by female workers, including hosts and hostesses (84.3%); food servers, nonrestaurant (73.9%); and waiters and waitresses (68.2%), while others are predominantly staffed by male workers, including chefs and head cooks (77.2%), dishwashers (76.5%), and cooks (59.8%) (36). The broad occupation and industry groups assessed in this report contain a diverse range of jobs, working environments, and workforces; detailed investigation may reveal opportunities for focused approaches to inform protection strategies for specific worker populations.

COVID-19 death rates and PMRs as estimated here combine the risk of both SARS-CoV-2 acquisition and infection fatality; no conclusions about either independent risk can be drawn from these findings (37). Usual occupation and industry were only available for decedents in 46 states and New York City, and estimates are only representative of those jurisdictions. Death certificates record usual occupation and industry, rather than current occupation and industry. This report restricted COVID-19 analyses to working-age decedents to minimize this limitation (7). However, many decedents aged 65 or over may have been working at the time of SARS-CoV-2 infection, and many decedents aged 15–64 may not have been working or may have been working in other occupations and industries, particularly because of unprecedented shifts in employment during COVID-19-related shutdowns (38). PMR estimates may be biased due to differential misclassification for occupations and industries with large employment changes in spring 2020. PMRs also measure relative cause-specific mortality. A higher PMR within one population compared with another does not indicate greater risk of COVID-19 mortality, nor many deaths from COVID-19, as PMRs are estimated relative to the number and distribution of all deaths within a given population (11). Low numbers of deaths also produced wide confidence intervals for some populations. PMRs and death rates as estimated here are not causal measures and effect estimates should be interpreted as hypothesis generating only, given the large number of comparisons and lack of hypothesis testing performed in this report.

COVID-19 death rates and PMRs varied across usual occupation and industry groups in 2020, showcasing the disparate impact of COVID-19 deaths on some worker populations. Sector-specific analyses would clarify COVID-19 mortality among individual occupations and industries and may examine the intersectional effects of work and demographic characteristics suggested by differences in COVID-19 PMRs by occupation and industry group within selected demographic populations. Work is a social determinant of health, and these findings highlight work-related SARS-CoV-2 transmission and COVID-19 mortality as health equity issues.

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List of Detailed Tables

Table 1. COVID-19 death rates among U.S. residents aged 16–64, by usual occupation group: 46 states and New York City, 2020

Usual occupation group	Number of COVID-19 deaths (percent)	Age-standardized COVID-19 death rate per 100,000 workers (95% confidence interval)
Total	48,435 (100.0)	28.6 (28.2–29.0)
Architecture and engineering	675 (1.4)	17.6 (15.5–19.7)
Arts, design, entertainment, sports, and media	673 (1.4)	21.2 (18.7–23.8)
Building and grounds cleaning and maintenance	3,089 (6.4)	43.7 (40.6–46.8)
Business and financial operations	1,058 (2.2)	10.6 (9.7–11.4)
Community and social services	1,080 (2.2)	34.5 (30.7–38.4)
Computer and mathematical	449 (0.9)	7.6 (6.7–8.5)
Construction and extraction	4,966 (10.3)	57.3 (53.7–61.0)
Education, training, and library	1,248 (2.6)	12.2 (11.3–13.2)
Farming, fishing, and forestry	689 (1.4)	54.8 (45.7–63.9)
Food preparation and serving related	2,859 (5.9)	57.5 (53.0–61.9)
Healthcare practitioners and technical	2,048 (4.2)	19.1 (17.8–20.5)
Healthcare support	1,619 (3.3)	31.2 (28.6–33.8)
Installation, maintenance, and repair	2,124 (4.4)	36.5 (33.5–39.5)
Legal	197 (0.4)	9.9 (7.8–11.9)
Life, physical, and social science	197 (0.4)	13.1 (10.4–15.7)
Management	3,700 (7.6)	15.4 (14.7–16.2)
Office and administrative support	3,821 (7.9)	21.1 (20.1–22.2)
Personal care and service	1,755 (3.6)	51.2 (46.0–56.4)
Production	4,245 (8.8)	44.8 (42.0–47.6)
Protective service	1,750 (3.6)	60.3 (53.5–67.2)
Sales and related	3,348 (6.9)	22.3 (21.1–23.4)
Transportation and material moving	6,845 (14.1)	56.0 (53.1–58.8)

NOTES: Death rates are directly standardized for age using 10-year age categories. Occupation-level COVID-19 death rates are estimated among workers aged 16–64 in 46 states and New York City with paid, civilian usual occupations. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 2. COVID-19 death rates among U.S. residents aged 16–64, by usual industry group: 46 states and New York City, 2020

Usual industry group	Number of COVID-19 deaths (percent)	Age-standardized COVID-19 death rate per 100,000 workers (95% confidence interval)
Total	47,913 (100.00)	28.3 (27.9–28.7)
Accommodation and food services	3,638 (7.6)	55.0 (51.1–58.9)
Agriculture, forestry, fishing, and hunting	1,131 (2.4)	40.7 (36.0–45.4)
Arts, entertainment, and recreation	816 (1.7)	30.0 (26.4–33.5)
Construction	5,391 (11.3)	42.3 (40.1–44.5)
Education services	2,239 (4.7)	13.5 (12.7–14.3)
Finance and insurance	1,055 (2.2)	12.2 (11.2–13.3)
Healthcare and social assistance	6,528 (13.6)	28.4 (27.2–29.6)
Information	548 (1.1)	18.5 (16.0–21.0)
Management, administrative, and waste services	2,765 (5.8)	38.9 (36.1–41.6)
Manufacturing	6,027 (12.6)	30.2 (28.8–31.5)
Mining	381 (0.8)	41.5 (33.0–49.9)
Other services (except public administration)	3,208 (6.7)	41.0 (38.2–43.8)
Professional, scientific, and technical services	1,509 (3.1)	11.4 (10.6–12.2)
Public administration	2,398 (5.0)	24.2 (22.5–25.8)
Real estate, rental, and leasing	560 (1.2)	13.6 (12.0–15.1)
Retail trade	4,157 (8.7)	28.1 (26.7–29.5)
Transportation and warehousing	4,550 (9.5)	49.6 (46.6–52.6)
Utilities	404 (0.8)	21.7 (18.3–25.1)
Wholesale trade	608 (1.3)	14.6 (13.0–16.2)

NOTES: Death rates are directly standardized for age using 10-year age categories. Industry-level COVID-19 death rates are estimated among workers aged 16–64 in 46 states and New York City with paid, civilian usual industries. National Health Interview Survey's administrative, support, and waste services and management of companies and enterprises industries are combined to align with the Current Population Survey's management, administrative, and waste services industry category. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 3. COVID-19 proportionate mortality ratios among decedents aged 15–64, by usual occupation group: 46 states and New York City, 2020

Usual occupation group	Total deaths	Number of COVID-19 deaths (percent)	Age-adjusted COVID-19 PMR (95% confidence interval)
Total	605,947	48,435 (8.0)	100.0 (…)
Architecture and engineering	9,732	675 (6.9)	81.8 (75.8–88.2)
Arts, design, entertainment, sports, and media	12,402	673 (5.4)	71.1 (65.8–76.6)
Building and grounds cleaning and maintenance	32,051	3,089 (9.6)	120.1 (116.5–123.7)
Business and financial operations	15,208	1,058 (7.0)	83.7 (78.5–88.9)
Community and social services	8,152	1,080 (13.2)	158.5 (151.4–165.7)
Computer and mathematical	8,816	449 (5.1)	62.7 (57.1–68.8)
Construction and extraction	81,546	4,966 (6.1)	77.9 (75.7–80.1)
Education, training, and library	15,259	1,248 (8.2)	97.4 (92.2–102.5)
Farming, fishing, and forestry	6,554	689 (10.5)	132.8 (123.1–143.1)
Food preparation and serving related	37,954	2,859 (7.5)	105.1 (101.6–108.5)
Healthcare practitioners and technical	22,710	2,048 (9.0)	107.5 (103.3–111.7)
Healthcare support	17,166	1,619 (9.4)	118.0 (113.0–123.0)
Installation, maintenance, and repair	32,763	2,124 (6.5)	80.3 (76.7–83.8)
Legal	3,687	197 (5.3)	63.5 (55.0–73.0)
Life, physical, and social science	3,337	197 (5.9)	73.1 (63.3–84.1)
Management	47,822	3,700 (7.7)	92.4 (89.6–95.3)
Office and administrative support	46,362	3,821 (8.2)	101.8 (98.9–104.7)
Personal care and service	21,208	1,755 (8.3)	105.7 (101.2–110.2)
Production	47,066	4,245 (9.0)	110.3 (107.4–113.2)
Protective service	15,121	1,750 (11.6)	142.6 (137.4–147.9)
Sales and related	47,605	3,348 (7.0)	89.8 (86.9–92.8)
Transportation and material moving	73,426	6,845 (9.3)	117.7 (115.4–120.0)

… Category not applicable.

NOTES: Proportionate mortailty ratios (PMRs) are internally adjusted to the age distribution of all U.S. resident decedents aged 15–64 with paid, civilian usual occupations using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 4. COVID-19 proportionate mortality ratios among decedents aged 15–64, by usual industry group: 46 states and New York City, 2020

Usual industry group	Total deaths	Number of COVID-19 deaths (percent)	Age-adjusted COVID-19 PMR (95% confidence interval)
Total	597,865	47,913 (8.0)	100.0 (…)
Accommodation and food services	48,730	3,638 (7.5)	103.7 (100.7–106.8)
Administrative, support, and waste services	29,733	2,724 (9.2)	118.3 (114.5–122.1)
Agriculture, forestry, fishing, and hunting	12,161	1,131 (9.3)	114.5 (108.6–120.4)
Arts, entertainment, and recreation	13,086	816 (6.2)	82.0 (76.5–87.8)
Construction	89,123	5,391 (6.0)	77.0 (75.0–79.1)
Education services	25,321	2,239 (8.8)	103.8 (99.9–107.7)
Finance and insurance	14,981	1,055 (7.0)	84.8 (79.5–90.0)
Healthcare and social assistance	66,589	6,528 (9.8)	118.7 (116.3–121.1)
Information	9,027	548 (6.1)	74.9 (68.7–81.4)
Management of companies and enterprises	556	41 (7.4)	87.6 (62.8–118.8)
Manufacturing	70,876	6,027 (8.5)	103.4 (101.1–105.7)
Mining	5,578	381 (6.8)	85.6 (77.2–94.6)
Other services (except public administration)	39,836	3,208 (8.1)	100.3 (97.1–103.5)
Professional, scientific, and technical services	25,815	1,509 (5.8)	71.5 (67.5–75.4)
Public administration	24,426	2,398 (9.8)	115.0 (111.0–119.0)
Real estate, rental, and leasing	7,628	560 (7.3)	88.1 (80.9–95.7)
Retail trade	55,420	4,157 (7.5)	96.4 (93.7–99.1)
Transportation and warehousing	46,665	4,550 (9.8)	119.3 (116.3–122.2)
Utilities	5,462	404 (7.4)	89.1 (80.6–98.3)
Wholesale trade	6,852	608 (8.9)	109.8 (101.3–118.9)

… Category not applicable.

NOTES: Proportionate mortality ratios (PMRs) are internally adjusted to the age distribution of all U.S. resident decedents aged 15–64 with paid, civilian usual industries using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 5. COVID-19 proportionate mortality ratios among decedents aged 15–64, by sex and usual occupation group: 46 states and New York City, 2020

Usual occupation group	Female	Male
	Age-adjusted COVID-19 PMR (95% confidence interval)	
Total	100.0 (…)	100.0 (…)
Architecture and engineering	48.0 (33.2–67.0)	81.5 (75.3–88.1)
Arts, design, entertainment, sports, and media	52.4 (44.3–61.5)	79.2 (72.6–86.3)
Building and grounds cleaning and maintenance	130.6 (122.0–139.6)	115.7 (111.5–119.8)
Business and financial operations	80.0 (72.9–87.5)	92.9 (85.5–100.7)
Community and social services	129.0 (116.7–142.3)	194.7 (180.3–209.9)
Computer and mathematical	59.6 (47.7–73.5)	62.2 (56.0–69.0)
Construction and extraction	34.7 (24.2–48.3)	74.8 (72.8–76.9)
Education, training, and library	102.1 (95.2–109.4)	107.3 (97.4–117.9)
Farming, fishing, and forestry	196.1 (160.3–237.7)	121.0 (111.4–131.2)
Food preparation and serving related	81.4 (76.1–86.9)	125.4 (120.8–130.0)
Healthcare practitioners and technical	105.8 (100.7–110.9)	136.5 (126.8–146.8)
Healthcare support	124.1 (118.6–129.7)	159.9 (142.0–179.4)
Installation, maintenance, and repair	67.0 (48.1–90.9)	76.7 (73.3–80.1)
Legal	61.3 (49.2–75.4)	69.9 (57.3–84.3)
Life, physical, and social science	66.9 (49.9–87.7)	75.6 (63.8–89.0)
Management	82.8 (77.6–88.3)	95.9 (92.5–99.2)
Office and administrative support	102.4 (98.8–106.0)	118.6 (113.4–123.8)
Personal care and service	114.1 (108.5–119.7)	109.8 (100.8–119.3)
Production	119.6 (111.8–127.8)	105.7 (102.6–108.9)
Protective service	123.7 (109.1–139.6)	142.6 (136.9–148.3)
Sales and related	79.9 (75.1–84.7)	97.7 (93.9–101.4)
Transportation and material moving	116.8 (108.5–125.5)	113.6 (111.3–116.0)

… Category not applicable.

NOTES: Proportionate mortailty ratios (PMRs) are internally adjusted to the separate age distributions of all U.S. resident decedents of each sex aged 15–64 with paid, civilian usual occupations using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed from COVID-19. PMRs based on fewer than 20 deaths across all age groups within that sex group are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 6. COVID-19 proportionate mortality ratios among decedents aged 15–64, by sex and usual industry group: 46 states and New York City, 2020

Usual industry group	Female	Male
	Age-adjusted COVID-19 PMR (95% confidence interval)	
Total	100.0 (…)	100.0 (…)
Accommodation and food services	77.6 (72.8–82.4)	124.0 (120.0–128.0)
Administrative, support, and waste services	118.7 (108.9–129.1)	115.9 (111.7–120.0)
Agriculture, forestry, fishing, and hunting	123.1 (103.0–145.9)	109.3 (102.6–116.3)
Arts, entertainment, and recreation	68.7 (59.1–79.5)	86.2 (79.6–93.1)
Construction	53.3 (43.7–64.4)	74.1 (72.2–76.1)
Education services	105.7 (100.5–110.9)	114.4 (107.2–121.8)
Finance and insurance	87.8 (80.6–95.4)	88.9 (81.3–97.0)
Healthcare and social assistance	122.6 (119.9–125.2)	140.8 (135.9–145.6)
Information	72.7 (62.1–84.6)	76.3 (68.8–84.4)
Management of companies and enterprises	* (…)	107.5 (70.2–157.6)
Manufacturing	104.9 (99.6–110.3)	100.7 (98.2–103.2)
Mining	* (…)	82.1 (74.0–90.9)
Other services (except public administration)	104.8 (98.1–111.8)	98.1 (94.4–101.9)
Professional, scientific, and technical services	62.9 (57.1–69.0)	76.5 (71.6–81.4)
Public administration	113.8 (106.0–122.0)	116.8 (111.9–121.8)
Real estate, rental, and leasing	67.8 (57.2–79.8)	99.6 (90.3–109.7)
Retail trade	84.3 (79.8–88.7)	105.5 (102.1–109.0)
Transportation and warehousing	105.6 (96.7–115.0)	117.2 (114.2–120.2)
Utilities	72.8 (52.2–98.7)	88.3 (79.5–97.9)
Wholesale trade	93.4 (74.4–115.8)	109.9 (100.7–119.7)

… Category not applicable.
* Estimate does not meet National Center for Health Statistics standards of reliability.

NOTES: Proportionate mortailty ratios (PMRs) are internally adjusted to the separate age distributions of all U.S. resident decedents of each sex aged 15–64 with paid, civilian usual industries using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed from COVID-19. PMRs based on fewer than 20 deaths across all age groups are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 7. COVID-19 proportionate mortality ratios among decedents aged 15–64, by race, Hispanic origin, and usual occupation group: 46 states and New York City, 2020

Usual occupation group	Hispanic	Non-Hispanic			
		American Indian or Alaska Native	Asian	Black	White
	Age-adjusted COVID-19 PMR (95% confidence interval)				
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Architecture and engineering	81.8 (69.1–96.2)	* (…)	76.3 (58.5–97.9)	123.0 (101.8–147.3)	103.2 (92.5–114.7)
Arts, design, entertainment, sports, and media	71.4 (61.5–82.5)	124.8 (84.2–178.2)	72.8 (47.6–106.7)	86.9 (73.9–101.6)	80.8 (71.5–91.1)
Building and grounds cleaning and maintenance	106.2 (102.0–110.4)	81.6 (60.3–107.8)	84.0 (61.3–112.4)	88.1 (82.1–94.4)	90.2 (83.0–97.9)
Business and financial operations	79.3 (69.4–90.3)	* (…)	76.4 (58.3–98.3)	97.5 (85.7–110.5)	106.3 (97.1–116.1)
Community and social services	116.2 (102.6–131.0)	160.4 (104.8–235.0)	78.4 (47.9–121.1)	149.5 (135.5–164.5)	185.4 (165.9–206.5)
Computer and mathematical	61.0 (47.4–77.4)	* (…)	55.4 (40.4–74.1)	96.8 (79.6–116.5)	82.6 (72.1–94.3)
Construction and extraction	91.1 (88.3–93.9)	71.4 (58.9–85.8)	88.3 (68.1–112.5)	65.7 (60.8–70.9)	61.6 (57.8–65.3)
Education, training, and library	80.0 (70.8–90.1)	107.3 (70.1–157.3)	66.9 (47.1–92.2)	121.8 (110.1–134.3)	115.7 (105.8–126.2)
Farming, fishing, and forestry	100.6 (92.1–109.7)	* (…)	* (…)	77.3 (57.8–101.4)	68.1 (54.8–83.6)
Food preparation and serving related	120.4 (115.6–125.1)	95.5 (71.7–124.6)	88.2 (73.9–104.4)	75.9 (70.0–82.1)	79.3 (72.9–86.0)
Healthcare practitioners and technical	90.8 (80.9–101.6)	136.4 (96.0–188.0)	159.5 (139.5–181.6)	131.1 (120.6–142.4)	129.5 (121.2–138.3)
Healthcare support	92.9 (83.2–103.5)	100.9 (66.5–146.9)	147.1 (112.8–188.6)	124.1 (115.6–132.9)	111.4 (100.5–123.0)
Installation, maintenance, and repair	90.2 (84.2–96.5)	84.4 (59.7–115.8)	88.3 (66.8–114.4)	88.5 (79.4–98.4)	83.9 (78.3–89.8)
Legal	63.0 (45.6–84.9)	* (…)	* (…)	90.2 (63.8–123.8)	84.7 (69.4–102.5)
Life, physical, and social science	82.5 (59.5–111.5)	* (…)	* (…)	102.4 (71.7–141.8)	91.7 (74.3–112.0)
Management	94.9 (90.0–99.8)	104.4 (78.0–136.9)	93.6 (81.6–107.0)	110.0 (101.9–118.5)	109.8 (105.1–114.5)
Office and administrative support	84.7 (79.2–90.4)	137.4 (109.7–169.8)	104.8 (88.9–122.7)	110.1 (104.5–115.8)	123.6 (118.4–128.7)
Personal care and service	86.4 (79.2–94.2)	127.8 (97.3–164.9)	91.7 (75.3–110.8)	105.1 (96.7–114.0)	105.7 (96.4–115.7)
Production	124.6 (120.5–128.7)	95.4 (72.2–123.6)	107.1 (92.7–123.0)	89.8 (83.6–96.4)	99.4 (94.3–104.5)
Protective service	93.9 (84.4–104.2)	134.7 (101.5–175.4)	166.7 (124.9–218.1)	152.6 (141.7–164.0)	156.2 (143.2–170.0)
Sales and related	95.3 (90.3–100.3)	109.3 (81.1–144.1)	95.8 (82.8–110.3)	94.2 (86.6–102.2)	107.2 (102.3–112.1)
Transportation and material moving	114.4 (111.2–117.6)	95.5 (76.4–118.0)	135.8 (118.0–155.6)	95.6 (91.9–99.3)	108.6 (104.1–113.1)

… Category not applicable.
* Estimate does not meet National Center for Health Statistics standards of reliability.

NOTES: Proportionate mortailty ratios (PMRs) are internally adjusted to the separate age distributions of U.S. resident decedents in each race and Hispanic-origin group aged 15–64 with paid, civilian usual occupations using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. PMRs based on fewer than 20 deaths across all age groups are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 8. COVID-19 proportionate mortality ratios among decedents aged 15–64, by race, Hispanic origin, and usual industry group: 46 states and New York City, 2020

Usual industry group	Hispanic	Non-Hispanic			
		American Indian or Alaska Native	Asian	Black	White
	Age-adjusted COVID-19 PMR (95% confidence interval)				
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Accommodation and food services	117.4 (113.3–121.5)	76.6 (56.9–101.0)	90.4 (78.6–103.6)	71.6 (66.4–77.1)	83.6 (77.9–89.5)
Administrative, support, and waste services	102.9 (98.3–107.5)	93.0 (64.0–130.6)	118.5 (91.3–151.3)	94.9 (87.9–102.2)	97.3 (89.6–105.4)
Agriculture, forestry, fishing, and hunting	99.0 (91.7–106.7)	65.4 (43.1–95.2)	87.1 (59.6–122.9)	82.9 (67.0–101.4)	87.5 (77.5–98.5)
Arts, entertainment, and recreation	76.2 (66.6–86.8)	116.7 (91.2–147.2)	87.0 (60.2–121.6)	86.5 (74.9–99.3)	86.1 (76.3–96.9)
Construction	91.1 (88.4–93.8)	68.8 (56.5–83.0)	80.0 (62.9–100.3)	65.2 (60.5–70.2)	63.2 (59.7–66.8)
Education services	82.4 (75.3–89.9)	135.2 (103.0–174.5)	68.3 (51.4–88.9)	118.0 (109.8–126.6)	119.3 (111.4–127.6)
Finance and insurance	71.4 (61.6–82.3)	* (…)	93.7 (73.6–117.7)	99.4 (87.2–112.7)	116.2 (106.6–126.4)
Healthcare and social assistance	93.4 (89.1–97.8)	141.7 (119.8–166.6)	142.3 (128.5–157.1)	125.6 (121.8–129.4)	132.0 (127.5–136.4)
Information	67.1 (55.4–80.5)	* (…)	91.4 (60.2–133.0)	95.7 (80.9–112.4)	89.8 (78.8–101.9)
Management of companies and enterprises	* (…)	* (…)	* (…)	* (…)	129.5 (82.1–194.4)
Manufacturing	122.7 (119.1–126.4)	94.7 (73.3–120.5)	110.3 (98.1–123.7)	91.2 (86.3–96.2)	102.0 (98.1–105.9)
Mining	97.7 (82.9–114.3)	* (…)	* (…)	113.8 (83.3–151.8)	89.6 (76.1–104.7)
Other services (except public administration)	97.7 (93.2–102.2)	65.7 (46.5–90.1)	70.6 (57.7–85.7)	95.9 (89.3–102.8)	95.4 (89.4–101.7)
Professional, scientific, and technical services	74.7 (67.0–83.0)	* (…)	59.5 (48.8–71.9)	90.3 (80.0–101.7)	93.6 (87.1–100.5)
Public administration	75.4 (68.1–83.3)	133.2 (109.1–160.9)	93.9 (72.1–120.1)	132.6 (124.2–141.6)	136.7 (128.0–145.9)
Real estate, rental, and leasing	87.6 (75.9–100.5)	* (…)	96.3 (64.0–139.2)	99.0 (82.2–118.2)	86.7 (74.9–99.7)
Retail trade	102.4 (98.0–106.8)	103.2 (78.7–132.8)	103.1 (90.1–117.5)	92.7 (86.2–99.7)	110.5 (105.9–115.2)
Transportation and warehousing	113.8 (109.6–118.0)	98.9 (71.6–133.2)	136.6 (118.5–156.7)	111.5 (106.4–116.7)	106.6 (101.2–112.0)
Utilities	93.8 (76.5–113.9)	* (…)	* (…)	104.4 (82.8–129.9)	110.8 (95.9–127.3)
Wholesale trade	110.0 (96.6–124.7)	* (…)	86.7 (56.7–127.1)	98.9 (79.5–121.5)	122.0 (107.0–138.5)

… Category not applicable.
* Estimate does not meet National Center for Health Statistics standards of reliability.

NOTES: Proportionate mortailty ratios (PMRs) are internally adjusted to the separate age distributions of U.S. resident decedents in each race and Hispanic origin-group aged 15–64 with paid, civilian usual industries using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. PMRs based on fewer than 20 deaths across all age groups are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 9. COVID-19 proportionate mortality ratios among decedents aged 15–64 who lived in the same state where they died, by U.S. Census Bureau region of residence and usual occupation group: 46 states and New York City, 2020

Usual occupation group	Midwest	Northeast	South	West
	Age-adjusted COVID-19 PMR (95% confidence interval)			
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Architecture and engineering	103.1 (86.7–121.6)	74.1 (61.8–88.1)	88.9 (78.2–100.6)	65.3 (54.5–77.6)
Arts, design, entertainment, sports, and media	97.4 (80.8–116.3)	75.2 (64.2–87.4)	65.5 (56.7–75.4)	54.6 (46.3–64.0)
Building and grounds cleaning and maintenance	108.6 (98.7–119.2)	122.0 (113.3–131.2)	115.6 (109.9–121.4)	135.8 (125.7–146.5)
Business and financial operations	81.9 (69.8–95.5)	93.9 (83.3–105.4)	84.7 (76.3–93.6)	71.5 (62.0–82.1)
Community and social services	164.3 (140.1–191.4)	125.3 (110.1–141.9)	194.6 (177.0–213.3)	115.5 (98.6–134.5)
Computer and mathematical	76.8 (61.3–95.1)	60.5 (49.3–73.5)	71.8 (61.6–83.1)	39.3 (30.4–50.0)
Construction and extraction	64.6 (59.5–70.1)	74.7 (70.0–79.4)	78.6 (75.2–82.0)	90.5 (85.5–95.5)
Education, training, and library	103.3 (89.3–118.7)	88.0 (78.1–98.9)	112.2 (102.9–122.2)	67.9 (58.3–78.7)
Farming, fishing, and forestry	115.3 (85.8–151.6)	40.7 (25.8–61.1)	116.4 (101.7–132.7)	179.6 (161.7–199.0)
Food preparation and serving related	96.9 (87.9–106.5)	123.5 (115.3–132.2)	92.6 (86.8–98.8)	109.6 (101.0–118.7)
Healthcare practitioners and technical	106.6 (95.4–118.7)	105.9 (96.7–115.8)	116.2 (108.6–124.2)	83.7 (74.0–94.3)
Healthcare support	108.6 (96.1–122.4)	121.3 (111.2–132.0)	121.6 (112.0–131.9)	92.1 (78.9–106.8)
Installation, maintenance, and repair	77.8 (69.7–86.5)	81.0 (73.4–89.2)	77.3 (72.0–82.8)	90.8 (82.9–99.3)
Legal	66.4 (44.1–96.0)	60.9 (45.5–79.9)	64.1 (49.8–81.1)	58.7 (42.3–79.3)
Life, physical, and social science	90.7 (63.5–125.6)	52.1 (35.4–73.9)	89.1 (70.7–110.7)	56.5 (40.4–76.9)
Management	95.2 (87.7–103.2)	89.3 (83.4–95.6)	96.8 (92.0–101.5)	84.5 (78.5–90.7)
Office and administrative support	112.1 (104.0–120.8)	92.9 (86.9–99.1)	107.4 (102.4–112.4)	90.4 (83.9–97.3)
Personal care and service	112.2 (99.4–126.2)	99.4 (89.8–109.9)	108.3 (99.8–117.3)	98.0 (88.9–107.7)
Production	106.8 (100.0–113.8)	110.6 (103.3–118.3)	101.6 (96.7–106.5)	150.3 (140.8–160.3)
Protective service	140.6 (123.2–159.7)	149.3 (136.7–162.8)	146.1 (135.2–157.8)	114.1 (101.3–128.1)
Sales and related	90.3 (82.6–98.4)	89.8 (83.5–96.5)	91.2 (86.4–96.1)	86.7 (80.4–93.4)
Transportation and material moving	117.0 (112.0–122.0)	124.0 (119.1–128.9)	114.6 (110.7–118.5)	134.9 (129.1–140.7)

… Category not applicable.

NOTES: Proportionate mortailty ratios (PMRs) are internally adjusted to the separate age distributions of U.S. resident decedents in each U.S. Census Bureau region (Midwest is Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; Northeast is Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Vermont; South is Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia; and West is Alaska, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) aged 15–64 with paid, civilian usual occupations using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. PMRs based on fewer than 20 deaths across all age groups are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 10. COVID-19 proportionate mortality ratios among decedents aged 15–64 who lived in the same state where they died, by U.S. Census Bureau region of residence and usual industry group: 46 states and New York City, 2020

Usual industry group	Midwest	Northeast	South	West
	Age-adjusted COVID-19 PMR (95% confidence interval)			
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Accommodation and food services	99.9 (91.8–108.6)	123.9 (117.8–130.0)	89.1 (84.1–94.1)	109.4 (101.9–117.4)
Administrative, support, and waste services	113.6 (102.3–125.9)	124.5 (115.6–133.9)	110.7 (103.8–117.9)	123.5 (113.9–133.7)
Agriculture, forestry, fishing, and hunting	88.8 (73.5–106.2)	59.7 (45.9–76.4)	111.1 (100.6–122.5)	153.3 (140.0–167.4)
Arts, entertainment, and recreation	104.0 (87.5–122.6)	76.3 (65.3–88.6)	79.4 (69.6–90.1)	75.1 (65.7–85.5)
Construction	66.4 (61.4–71.7)	74.1 (69.7–78.5)	76.5 (73.2–79.7)	89.4 (84.8–94.0)
Education services	107.9 (97.1–119.6)	88.7 (81.0–96.9)	122.6 (115.1–130.5)	76.4 (68.1–85.3)
Finance and insurance	91.4 (78.9–105.4)	79.9 (70.8–89.7)	94.0 (85.0–103.7)	64.7 (54.8–75.8)
Healthcare and social assistance	122.5 (116.7–128.3)	112.1 (107.7–116.5)	125.2 (121.2–129.3)	102.6 (97.0–108.2)
Information	93.6 (76.4–113.5)	68.7 (57.3–81.8)	80.6 (69.8–92.6)	58.9 (47.9–71.5)
Management of companies and enterprises	* (…)	* (…)	98.2 (62.9–146.1)	* (…)
Manufacturing	110.3 (105.8–114.8)	88.5 (83.5–93.4)	101.8 (97.8–105.9)	134.3 (128.3–140.4)
Mining	73.1 (45.8–110.7)	* (…)	95.7 (84.3–108.1)	87.3 (67.9–110.5)
Other services (except public administration)	88.9 (80.7–97.7)	99.7 (92.2–107.7)	104.6 (99.4–109.7)	101.4 (94.0–109.2)
Professional, scientific, and technical services	81.3 (71.3–92.3)	76.7 (69.4–84.5)	69.7 (63.7–76.0)	57.9 (51.6–64.9)
Public administration	129.6 (116.5–143.8)	107.3 (98.4–116.8)	129.2 (122.8–135.5)	79.6 (71.2–88.6)
Real estate, rental, and leasing	79.2 (60.9–101.3)	112.8 (97.2–130.1)	74.8 (63.7–87.2)	77.6 (64.8–92.3)
Retail trade	96.2 (89.0–103.9)	101.8 (96.3–107.4)	92.4 (87.9–96.8)	96.9 (90.6–103.6)
Transportation and warehousing	103.4 (95.5–111.9)	143.4 (137.4–149.3)	113.2 (108.4–118.0)	123.0 (115.1–131.3)
Utilities	90.0 (69.5–114.7)	68.3 (52.4–87.6)	109.0 (94.5–125.2)	70.0 (52.7–91.1)
Wholesale trade	100.2 (80.5–123.3)	104.5 (88.3–122.8)	108.6 (94.2–124.5)	119.1 (100.6–140.1)

… Category not applicable.
* Estimate does not meet National Center for Health Statistics standards of reliability.

NOTES: Proportionate mortailty ratios (PMRs) are internally adjusted to the separate age distributions of U.S. resident decedents in each U.S. Census Bureau region (Midwest is Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; Northeast is Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Vermont; South is Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia; and West is Alaska, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) aged 15–64 with paid, civilian usual industries using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. PMRs based on fewer than 20 deaths across all age groups are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 11. COVID-19 proportionate mortality ratios among decedents aged 15–64 who lived in the same state where they died, by U.S. Department of Health and Human Services region of residence and usual occupation group: 46 states and New York City, 2020

Usual occupation group	Region 1	Region 2	Region 3	Region 4	Region 5
	Age-adjusted COVID-19 PMR (95% confidence interval)				
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Architecture and engineering	85.7 (53.1–131.1)	76.8 (61.8–94.4)	75.8 (54.4–102.9)	101.0 (83.8–120.6)	104.9 (87.1–125.4)
Arts, design, entertainment, sports, and media	* (…)	70.3 (58.8–83.5)	78.4 (55.7–107.1)	65.9 (53.2–80.9)	92.5 (74.7–113.2)
Building and grounds cleaning and maintenance	130.5 (103.8–162.0)	116.2 (106.7–126.2)	146.1 (128.9–165.0)	115.7 (106.3–125.8)	108.6 (97.6–120.5)
Business and financial operations	110.7 (79.4–150.1)	90.8 (78.9–104.0)	100.8 (81.1–123.7)	91.3 (78.4–105.8)	77.6 (64.6–92.5)
Community and social services	177.5 (123.6–246.9)	109.0 (93.4–126.5)	154.7 (121.9–193.6)	206.9 (179.7–237.0)	171.4 (143.8–202.7)
Computer and mathematical	* (…)	65.5 (51.8–81.7)	67.0 (48.5–90.2)	84.8 (67.3–105.6)	79.6 (61.9–100.7)
Construction and extraction	71.0 (58.6–85.2)	81.5 (75.9–87.4)	80.0 (71.9–88.7)	66.3 (61.7–71.1)	63.6 (57.8–69.7)
Education, training, and library	99.1 (68.2–139.1)	79.9 (69.6–91.2)	80.7 (62.7–102.3)	123.3 (108.3–139.8)	102.3 (86.8–119.7)
Farming, fishing, and forestry	* (…)	* (…)	* (…)	131.5 (108.9–157.3)	119.9 (83.5–166.7)
Food preparation and serving related	104.0 (81.9–130.1)	131.2 (121.6–141.4)	96.6 (82.9–111.9)	90.8 (82.5–99.8)	96.0 (85.9–106.9)
Healthcare practitioners and technical	92.5 (66.9–124.6)	104.2 (93.8–115.5)	113.7 (96.3–133.4)	127.9 (116.3–140.4)	106.7 (94.1–120.4)
Healthcare support	150.2 (115.9–191.5)	112.2 (101.4–123.8)	126.7 (106.2–150.1)	132.0 (116.7–148.7)	113.7 (99.2–129.6)
Installation, maintenance, and repair	73.3 (53.9–97.5)	88.4 (78.8–98.8)	71.3 (59.3–85.1)	72.1 (64.7–80.2)	79.7 (70.6–89.7)
Legal	* (…)	60.2 (43.6–81.1)	* (…)	53.9 (34.5–80.2)	75.8 (49.5–111.0)
Life, physical, and social science	* (…)	52.3 (32.4–80.0)	* (…)	117.6 (84.4–159.5)	72.8 (46.2–109.3)
Management	85.4 (68.8–104.7)	87.3 (80.7–94.4)	90.3 (79.0–102.6)	96.8 (89.4–104.6)	91.4 (83.1–100.3)
Office and administrative support	97.8 (79.8–118.8)	86.3 (79.8–93.0)	111.7 (99.3–125.1)	110.7 (102.4–119.6)	113.7 (104.5–123.5)
Personal care and service	143.8 (110.0–184.7)	93.7 (83.1–105.2)	97.8 (80.0–118.4)	116.9 (103.5–131.6)	113.1 (99.0–128.8)
Production	123.0 (102.7–146.1)	118.7 (109.4–128.7)	103.4 (90.5–117.7)	104.4 (96.8–112.4)	107.3 (100.0–115.1)
Protective service	146.8 (103.9–201.6)	129.5 (117.4–142.5)	129.6 (106.1–156.7)	152.4 (135.7–170.7)	140.9 (121.6–162.5)
Sales and related	87.0 (69.4–107.7)	89.8 (82.5–97.6)	87.2 (75.7–100.0)	89.1 (82.0–96.7)	89.2 (80.8–98.3)
Transportation and material moving	116.7 (97.4–138.8)	126.8 (121.4–132.2)	116.0 (105.6–127.2)	111.8 (104.9–118.9)	116.0 (110.6–121.4)

See footnotes at end of table.

Table 11. COVID-19 proportionate mortality ratios among decedents aged 15–64 who lived in the same state where they died, by U.S. Department of Health and Human Services region of residence and usual occupation group: 46 states and New York City, 2020—Con.

Usual occupation group	Region 6	Region 7	Region 8	Region 9	Region 10
	Age-adjusted COVID-19 PMR (95% confidence interval)				
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Architecture and engineering	77.1 (63.4–92.8)	* (…)	81.7 (50.6–124.9)	68.7 (56.1–83.3)	* (…)
Arts, design, entertainment, sports, and media	66.5 (53.9–81.1)	117.1 (74.2–175.7)	* (…)	52.0 (43.0–62.4)	* (…)
Building and grounds cleaning and maintenance	106.8 (97.3–117.0)	98.4 (75.8–125.6)	136.0 (106.0–171.9)	134.5 (123.5–146.3)	139.8 (101.2–188.4)
Business and financial operations	75.6 (64.4–88.3)	99.8 (68.2–140.8)	88.6 (59.7–126.4)	67.2 (56.8–78.9)	* (…)
Community and social services	187.3 (163.2–214.0)	136.8 (86.7–205.3)	155.3 (98.4–233.0)	101.0 (83.5–121.0)	185.7 (113.4–286.7)
Computer and mathematical	58.7 (45.6–74.5)	* (…)	* (…)	39.6 (29.1–52.7)	* (…)
Construction and extraction	88.0 (83.2–92.7)	61.8 (50.1–75.4)	95.3 (81.3–111.0)	92.8 (86.6–99.3)	74.5 (57.6–94.8)
Education, training, and library	105.2 (93.0–118.4)	100.1 (68.5–141.4)	104.9 (73.1–146.0)	62.0 (51.6–74.0)	* (…)
Farming, fishing, and forestry	105.0 (85.8–127.3)	* (…)	* (…)	184.8 (164.2–207.2)	231.2 (173.2–302.5)
Food preparation and serving related	96.3 (87.4–105.9)	103.8 (82.8–128.5)	100.8 (77.8–128.4)	112.4 (102.4–123.2)	103.2 (74.4–139.5)
Healthcare practitioners and technical	107.1 (96.6–118.5)	107.1 (81.5–138.1)	88.0 (62.6–120.3)	80.9 (70.0–93.1)	* (…)
Healthcare support	111.7 (98.9–125.7)	94.9 (69.3–127.0)	78.8 (48.8–120.4)	94.8 (79.0–112.8)	* (…)
Installation, maintenance, and repair	86.2 (78.3–94.7)	73.7 (55.8–95.4)	79.5 (59.2–104.5)	93.3 (84.0–103.4)	81.8 (56.6–114.3)
Legal	65.8 (46.1–91.1)	* (…)	* (…)	60.4 (42.1–84.0)	* (…)
Life, physical, and social science	70.4 (48.8–98.4)	* (…)	* (…)	41.5 (25.4–64.2)	* (…)
Management	98.8 (91.3–106.7)	117.8 (98.1–140.2)	100.8 (83.6–120.5)	81.8 (75.1–88.9)	87.4 (66.0–113.5)
Office and administrative support	104.8 (96.7–113.3)	108.4 (89.8–129.9)	113.2 (92.6–136.9)	83.9 (76.8–91.5)	110.6 (84.8–141.8)
Personal care and service	105.0 (93.7–117.3)	94.1 (65.9–130.3)	104.3 (73.8–143.2)	91.2 (81.5–101.7)	99.3 (68.0–140.3)
Production	104.0 (96.0–112.5)	105.3 (87.8–125.2)	107.7 (84.6–135.2)	164.0 (152.6–176.0)	101.2 (75.3–133.1)
Protective service	143.5 (128.4–159.9)	122.3 (84.7–170.8)	139.0 (98.8–190.0)	105.8 (92.3–120.8)	* (…)
Sales and related	95.6 (88.3–103.4)	93.8 (75.7–115.0)	86.8 (69.2–107.4)	84.6 (77.6–92.1)	111.9 (86.0–143.2)
Transportation and material moving	111.2 (105.9–116.5)	127.5 (110.5–146.4)	116.0 (96.2–138.6)	137.0 (130.6–143.4)	127.3 (102.0–157.0)

… Category not applicable.
* Estimate does not meet National Center for Health Statistics standards of reliability.

NOTES: Proportionate mortality ratios (PMRs) are internally adjusted to the separate age distributions of U.S. resident decedents in each U.S. Department of Health and Human Services region (region 1 is Connecticut, Maine, Massachusetts, New Hampshire, and Vermont; region 2 is New Jersey and New York; region 3 is Delaware, Maryland, Pennsylvania, Virginia, and West Virginia; region 4 is Alabama, Florida, Georgia, Kentucky, Mississippi, South Carolina, and Tennessee; region 5 is Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin; region 6 is Arizona, Louisiana, New Mexico, Oklahoma, and Texas; region 7 is Kansas, Missouri, and Nebraska; region 8 is Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming; region 9 is California, Hawaii, and Nevada; and region 10 is Alaska, Idaho, Oregon, and Washington) aged 15–64 with paid, civilian usual occupations using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. PMRs based on fewer than 20 deaths across all age groups are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Table 12. COVID-19 proportionate mortality ratios among decedents aged 15–64 who lived in the same state where they died, by U.S. Department of Health and Human Services region of residence and usual industry group: 46 states and New York City, 2020

Usual industry group	Region 1	Region 2	Region 3	Region 4	Region 5
	Age-adjusted COVID-19 PMR (95% confidence interval)				
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Accommodation and food services	104.3 (84.0–128.1)	129.9 (121.4–139.0)	92.6 (80.6–105.9)	86.3 (79.2–93.9)	99.5 (90.4–109.3)
Administrative, support, and waste services	109.8 (84.5–140.2)	119.6 (110.0–129.7)	131.8 (114.2–151.5)	111.5 (101.7–122.1)	115.5 (103.0–129.2)
Agriculture, forestry, fishing, and hunting	* (…)	58.8 (40.2–83.0)	124.2 (90.9–165.6)	116.0 (100.5–133.2)	78.7 (61.0–99.9)
Arts, entertainment, and recreation	92.0 (58.3–138.0)	64.5 (53.7–77.0)	100.9 (74.9–133.0)	80.6 (66.6–96.7)	101.6 (83.6–122.2)
Construction	70.4 (58.8–83.6)	80.3 (75.1–85.9)	78.9 (71.2–87.2)	64.9 (60.6–69.4)	66.4 (60.8–72.5)
Education services	99.3 (75.4–128.4)	80.0 (72.1–88.6)	100.1 (84.7–117.4)	133.0 (121.0–146.0)	104.4 (92.5–117.5)
Finance and insurance	72.3 (48.8–103.2)	75.4 (65.5–86.3)	94.7 (75.3–117.5)	97.8 (84.3–112.8)	90.9 (77.0–106.6)
Healthcare and social assistance	137.9 (120.4–157.2)	105.9 (101.1–110.8)	123.4 (112.8–134.6)	137.6 (131.6–143.7)	123.9 (116.0–132.2)
Information	108.0 (68.5–162.0)	62.5 (50.6–76.4)	55.1 (35.7–81.4)	92.6 (75.6–112.3)	93.9 (74.2–117.2)
Management of companies and enterprises	* (…)	* (…)	* (…)	* (…)	* (…)
Manufacturing	98.8 (84.1–115.4)	97.0 (89.9–104.5)	95.6 (85.9–106.2)	105.1 (99.5–110.8)	109.3 (104.5–114.1)
Mining	* (…)	* (…)	* (…)	64.5 (43.8–91.6)	* (…)
Other services (except public administration)	112.5 (89.7–139.3)	103.3 (94.5–112.8)	96.4 (83.5–110.7)	105.7 (97.4–114.5)	91.1 (81.9–101.1)
Professional, scientific, and technical services	85.3 (64.2–111.0)	71.0 (63.2–79.5)	80.2 (66.1–96.5)	73.3 (64.1–83.5)	86.1 (74.7–98.6)
Public administration	92.7 (67.8–123.6)	99.5 (90.2–109.6)	119.6 (104.6–136.0)	135.0 (122.9–147.9)	126.4 (111.7–142.6)
Real estate, rental, and leasing	* (…)	107.2 (91.0–125.4)	93.2 (65.6–128.4)	66.5 (51.7–84.2)	83.6 (62.6–109.4)
Retail trade	101.2 (83.7–121.2)	100.2 (93.1–107.6)	101.3 (90.0–113.6)	90.8 (84.1–98.0)	94.9 (86.9–103.4)
Transportation and warehousing	110.7 (88.4–136.8)	140.6 (134.5–146.8)	111.6 (98.5–125.9)	112.0 (103.8–120.7)	106.7 (97.7–116.3)
Utilities	* (…)	65.9 (47.3–89.4)	78.8 (51.0–116.3)	111.3 (90.0–136.0)	82.3 (60.3–109.8)
Wholesale trade	* (…)	98.1 (80.1–118.9)	107.6 (77.6–145.5)	93.4 (74.4–115.8)	88.5 (67.6–114.0)

See footnotes at end of table.

Table 12. COVID-19 proportionate mortality ratios among decedents aged 15–64 who lived in the same state where they died, by U.S. Department of Health and Human Services region of residence and usual industry group: 46 states and New York City, 2020 —Con.

Usual industry group	Region 6	Region 7	Region 8	Region 9	Region 10
	Age-adjusted COVID-19 PMR (95% confidence interval)				
Total	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)	100.0 (…)
Accommodation and food services	93.7 (85.9–102.0)	103.5 (84.5–125.5)	108.2 (87.4–132.6)	113.8 (105.1–123.2)	103.1 (77.7–134.2)
Administrative, support, and waste services	105.0 (94.8–116.0)	95.5 (70.7–126.3)	114.1 (85.2–149.6)	119.5 (109.3–130.3)	151.7 (109.8–204.4)
Agriculture, forestry, fishing, and hunting	101.3 (87.5–116.6)	108.1 (76.1–149.0)	115.6 (82.2–158.1)	161.8 (145.8–179.1)	214.3 (169.1–267.8)
Arts, entertainment, and recreation	81.9 (68.0–97.9)	* (…)	96.4 (64.5–138.4)	69.0 (59.1–80.1)	* (…)
Construction	86.2 (81.5–90.9)	60.1 (49.2–72.8)	92.9 (79.7–107.6)	92.4 (86.6–98.4)	75.7 (59.6–94.8)
Education services	112.9 (103.1–123.5)	113.4 (87.9–144.0)	122.3 (94.6–155.7)	69.0 (60.1–78.9)	* (…)
Finance and insurance	92.4 (79.4–106.9)	95.1 (65.9–132.9)	90.1 (60.4–129.5)	58.5 (48.0–70.7)	* (…)
Healthcare and social assistance	115.5 (109.8–121.2)	117.8 (101.8–135.4)	112.6 (94.2–133.4)	97.1 (90.2–104.4)	110.8 (88.6–136.9)
Information	67.9 (53.7–84.6)	92.9 (58.2–140.7)	* (…)	54.2 (42.7–67.8)	* (…)
Management of companies and enterprises	81.7 (50.5–124.8)	* (…)	* (…)	* (…)	* (…)
Manufacturing	106.9 (99.7–114.4)	120.8 (105.6–137.6)	108.4 (88.3–131.7)	145.4 (136.4–154.9)	100.5 (79.4–125.7)
Mining	88.4 (77.6–100.2)	* (…)	94.9 (60.2–142.4)	74.7 (48.3–110.3)	* (…)
Other services (except public administration)	100.8 (93.0–109.1)	81.7 (63.3–103.8)	73.3 (54.6–96.4)	102.3 (94.1–111.0)	85.4 (60.7–116.8)
Professional, scientific, and technical services	64.3 (56.3–73.2)	59.8 (39.8–86.5)	66.8 (48.4–90.0)	55.9 (48.9–63.7)	65.3 (41.4–98.0)
Public administration	132.6 (121.2–144.7)	137.9 (108.1–173.3)	121.7 (94.9–153.7)	67.9 (58.9–77.8)	95.6 (64.0–137.3)
Real estate, rental, and leasing	84.0 (66.3–105.0)	* (…)	* (…)	72.0 (58.6–87.6)	* (…)
Retail trade	96.5 (89.6–103.8)	100.5 (83.0–120.7)	91.6 (74.7–111.2)	98.8 (91.5–106.4)	84.9 (64.2–110.3)
Transportation and warehousing	108.4 (100.8–116.3)	96.5 (78.6–117.2)	102.1 (81.0–127.1)	125.1 (116.3–134.4)	104.6 (78.6–136.5)
Utilities	113.6 (92.5–138.2)	* (…)	* (…)	49.6 (32.7–72.2)	* (…)
Wholesale trade	132.3 (108.8–159.3)	135.2 (86.6–201.2)	* (…)	112.8 (93.0–135.6)	* (…)

… Category not applicable.
* Estimate does not meet National Center for Health Statistics standards of reliability.

NOTES: Proportionate mortality ratios (PMRs) are internally adjusted to the separate age distributions of U.S. resident decedents in each U.S. Department of Health and Human Services region (region 1 is Connecticut, Maine, Massachusetts, New Hampshire, and Vermont; region 2 is New Jersey and New York; region 3 is Delaware, Maryland, Pennsylvania, Virginia, and West Virginia; region 4 is Alabama, Florida, Georgia, Kentucky, Mississippi, South Carolina, and Tennessee; region 5 is Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin; region 6 is Arizona, Louisiana, New Mexico, Oklahoma, and Texas; region 7 is Kansas, Missouri, and Nebraska; region 8 is Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming; region 9 is California, Hawaii, and Nevada; and region 10 is Alaska, Idaho, Oregon, and Washington) aged 15–64 with paid, civilian usual industries using 10-year age categories. PMR 95% confidence intervals are estimated using separate formulas for populations with 1,000 or fewer and more than 1,000 total observed deaths from COVID-19. PMRs based on fewer than 20 deaths across all age groups are suppressed. See Technical Notes in this report for more information.

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality, 2020.

Technical Notes

Nature and sources of data

Data in this report are based on information submitted by jurisdictions and coded by the National Center for Health Statistics (NCHS) through the Vital Statistics Cooperative Program. For the 2020 data year, all states, the District of Columbia, and New York City submitted mortality medical and demographic data in electronic data files to NCHS. Usual occupation and industry codes are available for decedents from 46 states and New York City. These data are coded through an agreement between NCHS and the National Institute for Occupational Safety and Health (NIOSH) (5). For more information on the variables that convey the decedent's usual occupation and industry for the 2020 data year, see the section "Classification of decedent's usual occupation and industry."

Death certificates are completed by funeral directors, attending physicians, medical examiners, coroners, or other people legally authorized to certify deaths. Data for 2020 are based on records of deaths that occurred during 2020 and were received as of July 27, 2021. Data for earlier years, excluding data on usual occupation and industry, can be obtained through the Centers for Disease Control and Prevention's Wide-ranging Online Data for Epidemiologic Research (WONDER) (39).

The U.S. Standard Certificate of Death and how it relates to race and Hispanic-origin classification

The U.S. Standard Certificate of Death, which states use as a model, was revised in 2003 (6). Before 2003, the certificate had not been revised since 1989 (15,40,41). The 2003 revision allows the reporting of more than one race (multiple races) (6). This change was implemented to reflect the increasing diversity of the U.S. population and to be consistent with the decennial census and the 1997 "Revisions to the Standards for the Classification of Federal Data on Race and Ethnicity" issued by the Office of Management and Budget (40). This revision replaced standards that were issued in 1977 (41). The new standards require the collection of more than one race, where applicable, for federal data (40) and require the collection of information on a minimum set of five races. More than the minimum number of race categories are reported on death certificates (6).

Multiple races in this report includes people with any combination of White, Black or African American, American Indian or Alaska Native (AIAN), Asian, and Native Hawaiian or Other Pacific Islander (NHOPI) races. However, estimates for non-Hispanic multiple race and non-Hispanic NHOPI workers in each occupation and industry group are not presented due to small counts. Records are classified within a single category (rather than as multiple races) if two or more specific selections within a standard category, such as Korean and Chinese, are reported.

Quality of race and Hispanic-origin data—Estimates for Hispanic, non-Hispanic AIAN, non-Hispanic Asian, and non-Hispanic NHOPI populations may be affected by inconsistencies in reporting Hispanic origin or race on the death certificate compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of Hispanic and non-Hispanic AIAN, Asian, and NHOPI decedents, as well as undercounts of these groups in censuses (42–45).

Cause-of-death classification

The mortality statistics presented in this report were compiled according to World Health Organization (WHO) regulations, which specify that member countries classify and code causes of death under the current revision of the *International Classification of Diseases* (ICD). ICD provides the basic guidance used in most countries to code and classify causes of death. Starting with deaths occurring in 1999, the United States began using the 10th revision (ICD–10) (46).

NCHS publishes its own volumes of ICD–10 to include modifications in use by NCHS (47).

Codes added or deleted in 2020

Starting with data year 2020, ICD–10 code U07.1, COVID-19, was added as a new, valid underlying cause-of-death code. No other codes were added to or deleted from the list of valid underlying cause-of-death codes in 2020. Information on the addition of U07.1, as well as codes added or deleted in previous years, is available from NCHS' "Instruction Manual, Part 9, ICD–10 Cause-of-death Lists for Tabulating Mortality Statistics" (9).

Quality of reporting and processing cause of death

The quality of mortality data is largely dependent on proper and thorough completion of death certificates by certifiers. Accuracy and completeness of information entered on death certificates can vary by state and over time.

One index of the quality of reporting on causes of death is the proportion of death certificates coded to Chapter XVIII—Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (ICD–10 codes R00–R99). Although it is impossible to determine which of these deaths truly occurred within each underlying cause, the total proportion coded to R00–R99 indicates the consideration given to the cause-of-death statement by medical certifiers. This proportion also may be used as a rough measure of the specificity of medical diagnoses. The percentage of all reported deaths in the United States assigned to Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, decreased from 1.14% in 2019 to 1.01% in 2020.

Detail on coding and classification of causes of death can be found in NCHS' Instruction Manual, Part 2 (47). The latest revisions to this instruction manual include entries for U07.1, the ICD–10 code assigned to COVID-19 (9,47).

Classification of decedent's usual occupation and industry

Occupation and industry information provided on death certificates was processed and coded through a collaboration with NIOSH (5). Occupation is the type of work that a person performs, or their job (such as teacher or cashier), while industry is the type of business in which a person works (such as an elementary school or grocery store). Some occupation groups primarily occur within a single industry group (for example, production workers primarily work in manufacturing industries and healthcare support workers primarily work in healthcare and social assistance industries). Other occupation groups occur across most or all industry groups (such as management, business and financial operations, and office and administrative support occupations).

Data on usual occupation and industry are available for 91% of decedents aged at least 15 in the 2020 National Vital Statistics System (NVSS) mortality files. Occupation and industry narratives were not coded for deaths that occurred in Arizona, North Carolina, Rhode Island, and the District of Columbia because these jurisdictions did not participate in the industry and occupation coding program in 2020. Iowa did participate, but because of its data collection method, data were inconsistent with other states' data and are excluded from the 2020 NVSS mortality files (5). Occupation and industry data were also missing for large percentages of records from decedents who lived in Ohio (11.0%) and Texas (5.8%) (5).

The U.S. Census Bureau categorizes occupations and industries into standardized codes and titles for the analysis of survey responses. Occupation and industry narratives from death certificates were coded to the standardized Census 2012 Occupation Codes (COC) and the Census 2012 Industry Codes (CIC). Narratives with insufficient information for coding, military occupations or industries, and narratives that indicated unpaid work (homemakers, students, volunteers, etc.) were coded to NIOSH and NCHS noncensus codes to capture all available information (5).

COCs and CICs were combined into broad groups using the National Health Interview Survey (NHIS) simple occupation and industry recodes (8). Additional information on occupation and industry coding within NVSS is available in "Industry and Occupation (I&O) Data as Applicable to Mortality Vital Statistics, 2020: History, Background, and Control Tables" (5).

Population denominator data from the Current Population Survey

Population denominator data for estimation of death rates were drawn from the Current Population Survey (CPS), a large, monthly survey that collects data on the U.S. labor force and is performed by the U.S. Census Bureau (10). A probability sample is applied to select about 60,000 U.S. households for voluntary participation each month. CPS participants must be noninstitutionalized civilians aged 15 and over, although employment data are largely restricted to those aged 16 or over. U.S. military members and people in institutions, including prisons, long-term medical care, and nursing homes, are not eligible. One survey participant in each household provides all responses for any eligible household members. Survey data are then weighted to represent the U.S. civilian noninstitutional population (10).

NCHS uses population denominator data from April for census years and July for all other years (29). All denominator data applied in this report were estimated using the April 2020 vintage and the CPS Basic Monthly data set in the U.S. Census Bureau's Microdata Access Tool (MDAT) (32). Within the microdata sample, data were restricted to jurisdictions that participated in the National Occupational Mortality Surveillance modernization program in 2020 (excluding Arizona, the District of Columbia, Iowa, North Carolina, and Rhode Island) and to people aged 16–64. Weighted CPS data applied in this report are representative of civilian noninstitutional populations within this restricted data universe.

Population estimates were generated for the crosstabulations of either industry or occupation group and age group, coded as 16–24, 25–34, 35–44, 45–54, and 55–64. CPS industry categories durable goods manufacturing and nondurable goods manufacturing were combined to align with NHIS' manufacturing industry category, and private households and other services, except private households were combined to align with NHIS' other services (except public administration) industry category for the estimation of death rates. Conversely, two NHIS industry categories, administrative, support, and waste services and management of companies and enterprises, were combined to align with CPS' management, administrative, and waste services industry category.

Computing death rates and confidence intervals

COVID-19 deaths for estimating death rates were restricted to working-age (15–64) decedents because deaths from COVID-19 in 2020 were acute and because usual occupation and industry may serve as reasonable proxies for current occupation and industry among those of working age (7). Decedents aged 15 were further excluded for estimating death rates because they are not represented in CPS workforce population denominator estimates.

Death rates are estimated as the number of deaths from COVID-19 in 2020 among workers aged 16–64 in a specified occupation or industry group residing in participating jurisdictions per 100,000 estimated population. Age-adjusted death rates (R') are used to compare mortality risks between groups and over time. However, they should be viewed as relative indices rather than as absolute measures of mortality risk (29). Age-adjusted death rates were computed via direct standardization—that is, by applying age-specific death rates (R_i) to the age distribution of the 2000 U.S. standard population aged 15–64 (Table I) (29).

$$R' = \sum_i \frac{P_{si}}{P_s} R_i$$

Table I. 2000 U.S. standard population aged 15–64

Age group (years)	Population *N* (percent)
Total	180,961,023 (100.0)
15–24	38,076,743 (21.0)
25–34	37,233,437 (20.6)
35–44	44,659,185 (24.7)
45–54	37,030,152 (20.5)
55–64	23,961,506 (13.2)

SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

P_{si} is the standard population in age group i and P_s is the total standard population (all age groups combined). Direct age-standardization was performed using 10-year categories, excluding age 15 (16–24, 25–34, 35–44, 45–54, and 55–64), to account for potential bias introduced by differential age structures in populations of workers.

Sampling variance data are not available from CPS for the specific study populations, and parameters from a proxy series were applied to estimate population denominator standard errors (SEs) that account for sampling variance under the survey design effect (13). α and β parameters were drawn from the parameters for the civilian labor force aged 16 and over (48). A level-to-level conversion estimated b as $b = (\alpha + \beta N)$, where N is the universe total (civilian noninstitutional population aged 16 and over in April 2020) (49). These parameters were then applied to estimate the approximate SE of the estimated population in each age group in each occupation and industry group (SE_{Pi}) as:

$$SE_{Pi} = \sqrt{b\left(x_{new} - \frac{x_{new}^2}{N}\right)}$$

where x_{new} is the estimated population and N is the universe total (13).

These approximate population denominator SEs were then applied to estimate SEs for each death rate accounting for sampling variability in the denominator (P_i) as well as random variability in the numerator (D_i). SEs for age-standardized death rates (R') were estimated as:

$$SE(R') = \sqrt{\sum_i \left(\frac{P_{si}}{P_s}\right)^2 R_i^2 \left(\frac{1}{D_i} + \left(\frac{SE(P_i)}{P_i}\right)^2\right)}$$

R_i is the age-specific death rate within a single age group-occupation or industry pair, D_i is the number of deaths from COVID-19 in the age group-occupation or industry pair, and all other parameters are defined as above (29). The 95% confidence interval (CI) is then estimated as:

$$R' - 1.96 \cdot SE(R')$$
$$R' + 1.96 \cdot SE(R')$$

CIs are approximate and should be interpreted with caution (13). No hypothesis tests were performed to compare death rates between worker populations, given the large number of comparisons and the uncertainty in denominator sampling variance estimates. Also, a higher absolute rate within one worker population compared with another does not denote a statistically significant difference.

Computing Proportionate Mortality Ratios and CIs

Proportionate mortality ratio (PMR) is estimated as the ratio of two proportions, or the proportion of deaths from the cause of interest within an exposed (for example, occupation or industry) group or subgroup divided by the proportion of deaths from the cause of interest within the full population, multiplied by 100 for ease of interpretation (11). It can also be thought of as the observed number of deaths from the cause of interest within an exposed population divided by the expected number of deaths from the cause of interest within the exposed population, multiplied by 100. A PMR over 100 indicates a higher proportion of deaths from the cause of interest within the exposed population than among all decedents combined (that is, deaths from COVID-19 among decedents in a specific occupation group comprise a greater proportion of all deaths in that group than among decedents in all occupation groups combined). PMRs are frequently applied to identify potential associations between exposures and cause(s) of death when inadequate population data are available for estimation of rates (11).

PMRs were internally adjusted for age to account for potential bias introduced by differential age structures in populations of workers. Table II illustrates the data structure applied to estimate age-adjusted PMRs for single occupation or industry groups. The subscript i represents the i^{th} age group (10-year age categories 15–24, 25–34, etc.). A_i denotes the observed number of deaths among workers in an occupation or industry group from the cause of death of interest within the i^{th} age category, with all other values calculated similarly.

Table II. Data structure applied to estimate age-adjusted proportionate mortality ratios for single occupation or industry groups

	Cause of death		
Occupation (or industry) group	Cause X	All other causes	All causes
Occupation Y	A_i	B_i	N_{1i}
All other occupations	C_i	D_i	N_{2i}
All occupations	M_{1i}	M_{2i}	T_i

SOURCE: National Center for Health Statistics.

The expected number of deaths ($E[A_i]$) from the cause of interest within a single occupation or industry group and age category is estimated as:

$$E(A_i) = N_{1i}\left(\frac{M_{1i}}{T_i}\right)$$

where M_{1i} is the total number of deaths from the cause of interest in the i^{th} age category and T_i is the total number of deaths in the i^{th} age category.

Observed and expected numbers of deaths from the cause of interest within a single occupation or industry group are then summed across all age categories and PMR is estimated as:

$$\text{PMR} = \frac{\sum_i A_i}{\sum_i E(A_i)} \cdot 100$$

A simplified example of estimation of an age-adjusted PMR for cause X in occupation Y for a population with two age groups (A and B) is shown below (Table III).

Age group A

$$E(A_A) = N_{1A}\left(\frac{M_{1A}}{T_A}\right)$$

$$E(A_A) = 100\left(\frac{200}{1000}\right) = 20$$

Age group B

$$E(A_B) = N_{1B}\left(\frac{M_{1B}}{T_B}\right)$$

$$E(A_B) = 400\left(\frac{200}{2000}\right) = 40$$

Age-adjusted PMR

$$\text{PMR} = \frac{\sum_i A_i}{\sum_i E(A_i)} \cdot 100$$

$$\text{PMR} = \frac{A_A + B_B}{E(A_A) + E(B_B)} \cdot 100$$

$$\text{PMR} = \frac{50 + 100}{20 + 40} \cdot 100 = 250$$

PMR 95% CIs are estimated using previously published formulas for populations with over 1,000 and 1,000 or fewer total observed deaths from the cause of interest (50). For PMRs with $\sum_i (A_i)$ over 1,000 from the cause of interest, the upper and lower 95% CIs were estimated as:

$$\text{CI} = \text{PMR} \pm 196 \frac{\sqrt{\sum_i \frac{M_{1i}M_{2i}N_{1i}N_{2i}}{T_i^2(T_i - 1)}}}{\sum_i \frac{M_{1i}N_{1i}}{T_i}}$$

For PMRs with $\sum_i (A_i) \leq 1000$ from the cause of interest, exact 95% CIs are estimated assuming Poisson distribution of the data (50). As observed deaths from a cause of death within each occupation or industry group and age category are distributed approximately as Poisson random variables, the total numbers of observed deaths from a cause of death within each occupation or industry group are also distributed as Poisson random variables. The mean of $\sum_i (A_i)$ is denoted as λ and PMR can be written as

$$\frac{\lambda}{\sum_i E(A_i)} \cdot 100$$

95% CIs are estimated by obtaining exact confidence limits for λ and dividing the resulting end points by $\sum_i E(A_i)$.

The lower limit of λ is denoted as L and the upper limit is denoted as U. L and U may be estimated in SAS software using the gaminv function or in R software using the qgamma function (51). The 95% CI is then estimated as:

$$\frac{L}{\sum_i E(A_i)} \cdot 100$$

$$\frac{U}{\sum_i E(A_i)} \cdot 100$$

Occupation and industry group-level PMRs are described in comparison with the total population for overall estimates or in comparison to the total demographic or geographic subpopulation for stratified estimates against a referent PMR value of 100.0 in each population. PMRs are considered elevated in this report if the lower bound of the 95% CI is over 100.0. No hypothesis tests were performed to compare PMRs between worker populations, given the large number of comparisons; and a higher absolute PMR within one worker population compared with another does not denote a statistically significant difference.

Suppression of unreliable estimates—An asterisk is shown in place of a crude or age-specific death rate or PMR based on fewer than 20 deaths. The limit of 20 deaths is a convenient, if somewhat arbitrary, benchmark, below which estimates are considered too statistically unreliable for presentation. For age-adjusted death rates and PMRs, the estimate is suppressed if the sum of the age-specific deaths is fewer than 20 (29).

Table III. Example data for estimation of an age-adjusted proportionate mortality ratio for cause X in occupation Y for a population with two age groups

Occupation	Cause of death		
	Cause X	All other causes	All causes
Age group A			
Occupation Y	50	50	100
All other occupations	150	750	900
All occupations	200	800	1000
Age group B			
Occupation Y	100	300	400
All other occupations	100	1500	1600
All occupations	200	1800	2000

SOURCE: National Center for Health Statistics.

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Contents

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