Age-adjusted COVID-19 Mortality Rates by Demographic Groups

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Introduction

A noteworthy aspect of the SARS-CoV-2 (COVID-19) pandemic is the disproportionate effect of the virus on people of different age groups. The elderly have a higher risk of mortality than working-age adults, and they also face a higher mortality risk than children (CDC, 2020). Figure 1 shows the monthly age-specific crude mortality rates (CMRs) by age group for the United States during 2020 and 2021. One can see that the mortality rates of children (0 to 17 years) and young adults (18 to 29 years) are essentially flat, with 1 death per million children and at most 14 deaths per million young adults. The mortality rate of intermediate adults (30 to 49 years) is somewhat higher, as is the mortality rate of older adults (50 to 64 years). However, the figure illustrates the striking disparity between the mortality rate of elderly adults (65 years or older) and the rest of the population, including children: The mortality rate of the elderly peaked at 1,577 deaths per million in January 2021. The mortality rate for the overall population is the population-weighted average of the rates across all five age groups.

Another important aspect of the pandemic is that it has spread throughout the country by region rather than all at once, affecting some states, and areas within them, before others, a situation which invites comparisons across states (McLaren, 2020; Benitez, Courtemanche, and Yelowitz, 2020). Finally, the literature analyzing the economic impact of the pandemic has emphasized that COVID-19 has affected individuals differently, suggesting comparisons across demographic groups (Gross et al., 2020).

The views expressed in this report are those of the author and are not necessarily those of the Federal Reserve Bank of Cleveland or the Board of Governors of the Federal Reserve System.

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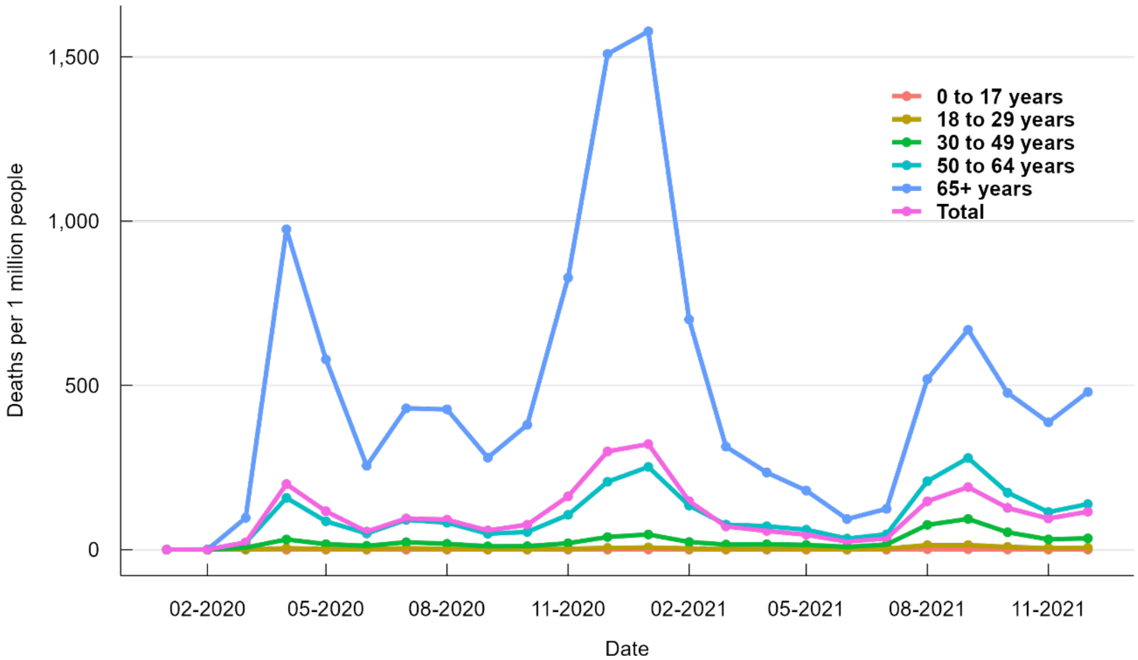
Figure 1. Crude Mortality Rate by Age Group in the United States



Note: Crude mortality rate is defined as deaths per million people in each age-specific subgroup.
Sources: COVID-19 deaths from the CDC, population data from the US Census Bureau, and author's calculations.

In this *District Data Brief* I argue that a comparison of the mortality rates across states should account for differences in the age distributions of the populations of interest, especially if one aims to make comparisons across demographic groups. I further emphasize that failing to make this adjustment may lead to incorrect conclusions.

I use publicly available data on COVID-19 deaths from the Centers for Disease Control and Prevention (CDC) and data on the age distribution of the states' populations from the US Census Bureau's Population Estimates Program to calculate cumulative age-adjusted mortality rates (AMRs) from January 2020 to January 2022 across the Fourth Federal Reserve District states and the nation for various demographic groups, including by sex, race, and ethnicity.[1]

Age-adjusted mortality rates

In the same way that CMRs (expressed as deaths per million people) allow for more accurate comparisons between locations with different population sizes than simply comparing total death counts, AMRs

[1] The region the Federal Reserve Bank of Cleveland serves—the Fourth Federal Reserve District—comprises Ohio and parts of Kentucky, Pennsylvania, and West Virginia.

provide a fairer comparison among populations and locations with different age distributions (Missouri Department of Health & Senior Services, 2021).

Adjusting the mortality rate of a given population by age to compare it with a different population requires selecting a "standard" population. One can then compare each group with the standard population first and then with each other. In this exercise I select the standard population from the 2019 estimates of the age distribution of the population of the entire United States. A crucial element of the adjustment process is knowing the age distribution of the populations of interest, which I also measure as of 2019, and the standard population. Although the adjustment methods I describe are fairly common in epidemiological studies, I believe the comparison of AMRs has not been emphasized enough in the popular press or in the numerous tracking websites that offer COVID-19 statistics. (See Curtin and Klein (1995), CDC (2021), and Kelsey and Gold (2017) for additional details on the adjustment methods.)

Direct adjustment

The direct adjustment requires knowing the age-specific mortality rates of the populations of interest and the age distribution in the standard population. The CDC data on COVID-19 deaths by sex provide the necessary information to construct the age-specific mortality rates by age group and sex. The method multiplies the age-specific mortality rates in the population of interest by the population counts in the same age group in the standard population to obtain the expected death count by age group as if the population of interest had the same age distribution as the standard population. I define the standard population as the sum of all male and female individuals in the United States.

Table 1 illustrates this calculation in Ohio. The table presents the known age-specific mortality rate (death count per million people) for each of five age groups (column 1) for female and male individuals (columns 2 and 3, respectively) in Ohio. The standard population is the sum of female and male individuals in each age group in the United States (column 4). The expected deaths for each sex are obtained by multiplying the age-specific rates by the standard population (columns 5 and 6).

Dividing the sum of expected deaths for female individuals, 795,511, by the sum of the standard population, 328.2 million, yields the AMR for female individuals in Ohio of 2,424 deaths per million. This number clearly differs from the CMR of 2,759 deaths per million, illustrated in the last row of column 2 in the table.

Performing the same calculation for the male population allows for a direct comparison of the AMRs between female and male individuals in Ohio. Repeating this calculation for the female and male populations in other states allows for a comparison across states.

Table 1. Direct Calculation of Age-adjusted Mortality Rate, Ohio

Age group	Age-specific rate		Standard population	Expected deaths	
	Female	Male		Female	Male
0 to 17 years	7.93	8.35	73,039,150	579	610
18 to 29 years	61.17	78.18	53,728,222	3,287	4,201
30 to 49 years	414.33	584.93	84,488,200	35,006	49,419
50 to 64 years	1,821.92	2,872.54	62,925,688	114,646	180,757
65+ years	11,875.95	16,016.41	54,058,263	641,993	865,819
Total	2,758.56	3,252.39	328,239,523	795,511	1,100,806

Notes: Age-specific mortality rates are expressed in deaths per million. Data cover the period of January 1, 2020, through January 15, 2022.
Sources: COVID-19 deaths from the CDC, population data from the US Census Bureau, and author's calculations.

Indirect adjustment

COVID-19 death data are often suppressed for confidentiality reasons when death counts for a specific population are small. This suppression is more prevalent for data that involve the race or ethnicity of the individuals. Thus, the age-specific mortality rates for racial or ethnic groups are not readily available, and the direct method for adjusting mortality rates by age is not applicable. An indirect method for adjusting mortality rates by age group can be used, however. The indirect method requires knowledge of the total death count by demographic group and the age-specific mortality rate in the standard population. This method also requires knowledge of the age distribution of the population of interest. To calculate the AMR for racial and ethnic groups, I consider only the three largest groups in the population: non-Hispanic Black, Hispanic, and non-Hispanic white. For the standard population, I sum these three groups at the national level.

The indirect adjustment method multiplies the age-specific mortality rate of the standard population by the age-specific population count in the group of interest to obtain the *expected deaths* in each age group as if the population of interest experienced the same mortality rate as the standard population. Table 2 illustrates this calculation for the non-Hispanic Black, Hispanic, and non-Hispanic white populations in Ohio. Columns 2, 3, and 4 show the population count in each age group for each of these racial groups. Column 5 shows the age-specific mortality rate for each age group in the standard population. Finally, the last three columns show the expected deaths, calculated by multiplying the age-specific population by the age-specific mortality rate in the standard population.

Table 2. Calculation of Expected Deaths in Ohio

Age group	Population			Mortality rate in standard population	Expected deaths		
	Black	Hispanic	White		Black	Hispanic	White
0 to 17 years	389,309	167,168	1,827,503	10.03	4	2	18
18 to 29 years	278,984	94,298	1,370,568	99.15	28	9	136
30 to 49 years	369,435	127,790	2,219,964	639.27	236	82	1,419
50 to 64 years	258,514	52,919	1,960,815	2,563.49	663	136	5,027
65+ years	185,110	28,287	1,790,242	11,821.07	2,188	334	21,163

Notes: Mortality rates are expressed in deaths per million. Both Black and white groups are non-Hispanic.
Sources: COVID-19 deaths from the CDC, population data from the US Census Bureau, and author's calculations.

Finally, I divide the number of observed total deaths by the number of total expected deaths for each racial group to obtain the standardized mortality ratio (SMR). Table 3 illustrates this calculation. For example, the SMR for the Hispanic population, 1.12, is obtained by dividing 628 observed deaths by 563 expected deaths. A ratio of observed to expected deaths larger than 1 indicates a higher mortality risk in the population of interest compared to that in the standard population, while a ratio smaller than 1 indicates a lower mortality risk. In order to compare any two racial populations, it is enough to compare the corresponding SMRs.

Table 3 also includes the CMR for each racial group calculated as the ratio of observed deaths to the population count (expressed in millions). A comparison of CMRs leads to the conclusion that the white population exhibits a higher mortality risk because this group has the largest CMR. However, a comparison of the SMRs, in contrast, shows that Black and Hispanic populations exhibit greater mortality risks, thus underscoring the necessity of adjusting mortality rates by age when comparing across different populations.

Table 3. Calculation of Standardized Mortality Ratios in Ohio

Race/ethnicity	Population	Observed deaths	Total expected deaths	CMR	SMR
Black	1,481,352	4,142	3,119	2,796.09	1.33
Hispanic	470,462	628	563	1,334.86	1.12
White	9,169,092	29,952	27,763	3,266.63	1.08

Notes: CMR is the crude mortality rate expressed in deaths per million. SMR is the standardized mortality ratio of observed deaths to expected deaths. Data cover the period of January 1, 2020, through January 15, 2022. Both Black and white groups are non-Hispanic.
Sources: COVID-19 deaths from the CDC, population data from the US Census Bureau, and author's calculations.

Disparities in mortality rates in the Fourth District states and the United States

Age adjustment allows for comparisons of mortality rates across different populations and locations. Table 4 compares the mortality risks for each of the Fourth Federal Reserve District states and the nation as a whole. The table shows the disparities in mortality risks, calculated as the ratio of CMRs or AMRs for female populations compared with those for male populations and for non-Hispanic Black, Hispanic, and non-Hispanic white populations. A ratio larger than 1 indicates that the group in the numerator exhibits a larger mortality risk than the group in the denominator. A ratio smaller than 1 shows the reverse.

Using the unadjusted mortality rates, I reach the conclusion that across Fourth District states and the nation, male individuals show a greater mortality risk than female individuals as the ratios of CMRs are all less than 1. A similar conclusion is drawn using AMRs. However, when comparing the non-Hispanic Black, Hispanic, and non-Hispanic white populations, all four of the District states show a greater risk for the non-Hispanic Black population than the non-Hispanic white population using AMRs, while the opposite conclusion is obtained using CMRs. In the United States as a whole, both the CMR and AMR show a greater risk for the non-Hispanic Black population. For Hispanic populations, except in West Virginia, AMRs show a mortality risk for this group at least as great as that for the non-Hispanic white population, while the CMRs show the opposite.

The different conclusions regarding mortality risks between non-Hispanic Black and Hispanic populations compared to non-Hispanic white populations depend on the differences in the age distributions of these groups. For example, if a given Hispanic population is younger than its comparative white population, a higher number of observed deaths than expected deaths in the Hispanic population means the mortality risk is greater because it is known that COVID-19 is generally less deadly for younger people.

Table 4: Disparities in COVID Mortality Risk in the Fourth District States and the United States

Area	CMR			AMR		
	Female/ Male	**Black/ White**	**Hispanic/ White**	**Female/ Male**	**Black/ White**	**Hispanic/ White**
Kentucky	0.9	0.9	0.4	0.8	1.2	1.1
Ohio	0.8	0.9	0.4	0.7	1.2	1.0
Pennsylvania	0.9	0.9	0.5	0.7	1.5	1.2
West Virginia	0.8	0.8	0.3	0.7	1.1	0.7
United States	0.8	1.1	0.9	0.7	1.7	1.9

Notes: CMR is the crude mortality rate. AMR is the age-adjusted mortality rate. Data cover the period of January 1, 2020, through January 15, 2022. Both Black and white groups are non-Hispanic.
Sources: COVID-19 deaths from the CDC, population data from the US Census Bureau, and author's calculations.

Conclusion

Comparing mortality rates among different demographic groups using CMRs may be misleading because doing so neglects the consideration of age distributions across the racial demographic groups. Age distributions are an important consideration in the current COVID-19 pandemic because the virus affects age groups differently, and one’s risk of death increases with age. If age-specific death rates for a given population are available, performing direct or indirect adjustments to the CMR can result in a more accurate measure of death risk when comparing different demographics. These adjustments are necessary to account for discrepancies in age distributions among different populations.

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