Title: Death, Inequality, and the Pandemic in the Nation's Capital

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Abstract

Objectives. This study describes trends in all-cause mortality and Years of Life Lost (YLL) before and after COVID-19 in Washington, DC, disaggregated by age, sex, race, and ward of residence as a proxy for socioeconomic status.

Methods. We obtained mortality data from DC's death records and calculated sex-age-race-specific death rates using information from the census and YLL using the life table approach and the difference in life expectancy between people with and without a COVID-19 diagnosis.

Results. In 2020 there were 990 more deaths (139 per 100K) in the capital compared to the annual average over the previous five years, and 676 of these deaths (94.8 per 100K) listed COVID-19 as one of the causes of death. Excess deaths in 2020 were higher in April, May, and December than in other months by 100-300 deaths; were higher for men than women by about 10.2%, and occurred almost entirely among residents 55 and older. Moreover, excess deaths were higher for those identified as Black or Hispanic by about 300 or 150 per 100K, respectively—the highest proportional increase (almost twofold) for Hispanics in 2020 compared to the five previous years. Additionally, neighborhood differences reflect ethnic and socioeconomic inequality: increases in mortality during 2020 were most significant for those wards with the most Black and Hispanic residents and the lowest income and employment rates, corresponding with historical trends in illness and mortality. Indicating the intersectionality of these differences, in 2020, Black and Hispanic males lost 6 and 7 expected years of life, respectively, and Black and Hispanic females lost 5 and 6 years, respectively. In contrast, Whites lost no years of life during the pandemic.

Conclusion. Examining mortality rates and life expectancy within population subgroups and using ward-level data allows us to understand how the pandemic has exacerbated health inequalities. Local-level sociodemographic research like ours reveals intersectional inequalities often obscured by the national statistics often used in popular and scholarly discourse. Our findings should promote actionable local policy to decrease YLL from preventable deaths and earlier mortality from COVID-19 among disadvantaged groups.

Introduction

Death rates due to COVID-19, based on official statistics, have grown exponentially in the US. As of August 2022, the CDC has reported more than 1.03M deaths from COVID-19 in the US (CDC, 2020). The burden of COVID-19 has been unevenly borne, depending on the ability to self-protect by working from home, pre-existing chronic conditions, and adequate access to health care. Herein we quantify the extent to which the pandemic has impacted health outcomes in Washington DC, a city of approximately 712,816 people with over a thousand documented COVID-19 deaths across the first two years of the pandemic (CDC, 2020; US Census Bureau, 2021). DC also has a well-documented history of inequity, which we explore by looking at the extent to which the pandemic has widened pre-existing gaps across sociodemographic groups in all-cause mortality, cause-specific mortality, and life expectancy. As such, we offer a close, surgical examination of the unequal mortality burden during COVID-19 for a large, unequal city like the nation's capital.

We look at all-cause mortality because of several well-documented limitations to monitoring and reporting COVID-19-related deaths. For example, COVID-19 might not have been listed as a cause of death in death certificates and, therefore, under-reported because people who died had not been diagnosed or died of other comorbidities. COVID-19 might have also impacted deaths by increasing mental health disorders, violence, substance abuse (McKnight-Eily, 2021), and the risk of otherwise preventable deaths made more likely by reduced use of health care services (Katz, 2020). Reductions in mobility and social distancing mandates might, on the other hand, have prevented non-COVID deaths for some groups. For example, flu transmission decreased by 20 percent (Baker et al., 2020), potentially saving lives. Given these complexities, tracking all-cause mortality allows us to account for changes possibly induced by policy and behavioral responses while avoiding potential measurement bias from focusing on COVID-19 mortality alone.

Mortality and Years of Life Lost (YLL) capture different facets of health status in the population: the former captures overall trends by demographic strata, and the latter better reflects health inequities. While mortality is the probability of dying in a given year, YLL captures premature mortality compared to how long a person is expected to live. YLL provides richer, finer-grained information than the mortality rate alone because strata (e.g., by race and sex) with vastly different life expectancies might have similar mortality rates. Indeed, dying young is a salient indicator of inequality with intergenerational implications for social mobility, given the well-documented economic and emotional difficulties of single-parent families (Krueger et al., 2015) and orphans (Poulton et al., 2002).

Historically, the leading causes of death in Washington, DC, have been heart disease, cancer, stroke, and diabetes (Garner et al., 2016). The burden of these illnesses has been unequally distributed across DC's eight wards, which are highly stratified along socio-economic and racial lines. DC's eight wards (electoral districts) have approximately 88,000 residents each. Prior research has reported a staggering difference of up to 15 years in life expectancy between residents of Ward 8 and Ward 3, which are less than 10 miles apart (Roberts et al., 2020). We look at the changing demographics of all-cause mortality, the changing composition of causes of death between 2015-2019 (pre-pandemic) and 2020 (mid-pandemic), and the impact of COVID-19 on YLL across demographic groups in DC.

Data

We use several data sources to compute mortality rates and YLL. As a primary source of information on mortality across socio-demographic groups, we use death certificates for 2015-2020 from the DC Department of Health's Vital Records (CDC, 2022a). These death certificates represent DC residents who passed away in DC (rather than elsewhere) in a given year and contain information on the deceased person's name, date of birth, date of death, zip code of residence, race, age, sex, underlying causes, and manner of death.

For contextual, demographic information on DC, we use the Census Bureau's American Community Survey (ACS) 1-year estimate tables for 2015-2019 (US Census Bureau, n.d.). For 2020, we use the ACS experimental data tables, which adjust for non-response bias due to the challenges of conducting the Census during the pandemic (US Census Bureau, 2021). Except for the 2020 ACS race distribution table, all other ACS data tables are available at the same level of demographic grouping (age, sex, and ward) over the 2015-2020 study period. To create ward-level demographic strata, we merge the residential zip codes in the DC death certificates with the wards' longitude and latitude shape files (Open Data DC) and ward-level demographic data (hosted on the DC Office of Planning website; DC Data | op). As of this writing, the latest DC wards shapefiles are from 2012 (Planning Area Data | op); therefore, we use the 2012 DC wards shapefile to map the eight wards onto the addresses of deceased DC residents.

We use 2019 sex-and race-specific US life tables (Arias et al., 2022), the latest available at the time of this writing. Finally, we use the 2020 COVID-19 case counts from the CDC to estimate COVID prevalence (CDC, 2021) and the age-adjusted race-specific risk rates for COVID deaths in 2020 published by the CDC (Truman, 2022).

Methods

Mortality rates

We analyze the DC all-cause mortality rate by demographic strata (i.e., age, race, sex, and ward) by combining death certificate counts with ACS data. As the ACS represents 1-year estimates based on annual data collected from a sample of housing units, these data present a margin of error (US Census Bureau, b). We report the ACS confidence intervals as supplemental material but do not account for the lower and upper bounds of the live population (our denominator) in the mortality rate estimates because deaths (our numerator) represent both population values and rare events. The rate is immune to changes in the denominator estimates. The pandemic disrupted ACS data collection in 2020, and thus counts by demographic strata are missing. To compare 2020 mortality rate values with previous years, we assume that the racial distribution of DC in 2020 would be the same as in 2019. We consider this a reasonable assumption given that the year-on-year changes in the racial composition of DC are historically small (US Census Bureau, a).

We further report changes in the documented causes of death pre-and post-pandemic to understand if there are indirect consequences of COVID-19 on other cause-specific deaths. While studying changes in all-cause mortality is less prone to measurement error, it is still useful to report changes in the documented causes of death pre-and post-pandemic to understand if there are indirect consequences of COVID-19 on other cause-specific deaths. The contraction of health care consumption at the start of the pandemic (Ziedan et al., 2022) and the reductions in mobility under social distancing mandates might have impacted deaths in unforeseeable ways, leading to an increase in deaths that are typically preventable, such as through increased mental health disorders, violence, and substance abuse (McKnight-Eily, 2021). In other words, we anticipate that COVID-19 might increase reported deaths from other causes, either because COVID-19 was underreported in surveillance data, the pandemic derailed health services on potentially avoidable deaths, or increased violence and accidental deaths. We also anticipate that these excess deaths might not be equally borne across all groups; therefore, we report the demographic characteristics of those more likely to die from them.

Years of Life Lost (YLL)

YLL is a summary measure of the difference in mortality between people with and without a condition. We use the life table approach to calculate YLL (Gray et al., 2010). We construct the COVID-specific life table for DC using all-cause mortality rates from CDC's National Center for Health Statistics by single year of age and sex; DC-specific COVID prevalence by age, sex, and race (Appendix A.1); and national-level relative mortality risk by race (Appendix A.2) for those with and without COVID-19. We scale the all-cause mortality of those with COVID relative to those without. We compute a scale-up factor (Pharoah & Hollingworth, 1996), θ_u, ranging between r and 1, that incorporates the relative risk (r) and COVID prevalence (p) as shown in Equation 1:

$$u = \frac{r}{pr+(1-p)} \qquad \text{Eq. (1)}$$

Existing CDC life tables estimate the probability of dying between a given age x and age x+1 (commonly denoted as q_x). Thus, q_x represents the number of individuals dying between age x and x+t divided by the number of individuals reaching exact age x.

We then estimate the number of person-years lived, denoted as L_x, between age x and x+t, assuming that deaths are evenly distributed, as follows:

$$L_x = \left(\frac{time\ interval}{2}\right) * Number\ of\ persons\ alive\ at\ age\ x = t \qquad \text{Eq. (2)}$$

We calculate the total number of person-years that would be lived at a given age by cumulating the number of person-years lived from the oldest to the youngest age. We then calculate the average remaining lifetime (in years) for a person who survives a given age interval by dividing the total number of person-years lived from age x (T_x) by the number of persons alive at age x (l_x) (i.e., life expectancy = T_x/l_x). For deaths that occurred within the age interval x and x+t, the crude expected YLL equals the longest life expectancy for each cohort in the absence of COVID-19 minus the life expectancy with the condition.

Results

Mortality rates

As described above, we track all-cause mortality to avoid measurement bias in focusing on COVID-19 mortality alone. Figure 1 presents the age distribution of the mortality rate per 100,000 people in Washington, DC, from 2015-2020. In 2020, there were 990 excess deaths compared to the previous five years' average. The increase in the death rate was concentrated among residents aged 55 and over.

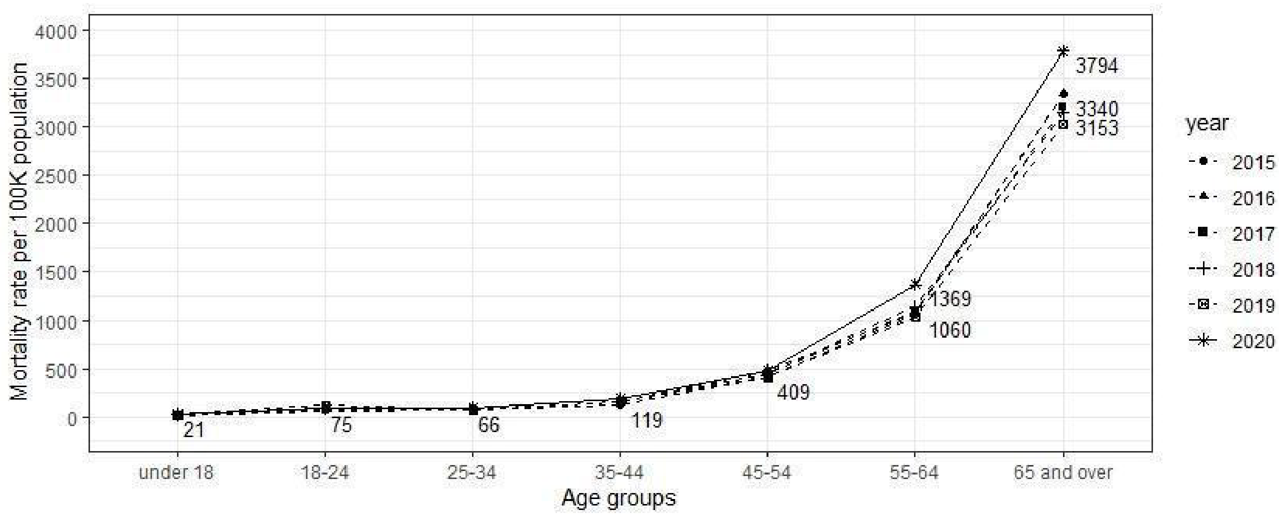

Figure 1: Between 2020 and the previous five years, excess deaths show that residents 45 and older are most affected.

When analyzing death counts by month, as in Figure 2, we observe significant increases in mortality in April, May, and December 2020, compared to the same months in previous years. The mayor of DC declared the state of emergency on March 11th (Portnoy et al., 2020), the same day the World Health Organization declared COVID-19 to be a worldwide pandemic and two days before POTUS declared COVID a National Emergency (Hawkins et al., 2020). On March 16th, public schools closed in the district, and for the next two months, non-essential business and indoor venues were closed, and large gatherings were banned (Stein & Natanson, 2020). DC recorded its first COVID case on March 7th and its first COVID death on March 20th (DoH, 2020a, 2020b). Given what we have learned about transmissibility and mortality probabilities from COVID (Davies et al., 2020), it is very likely that the first cases happened at least one or two months earlier.

Despite the stay-at-home orders, there were 680 deaths in April 2020 and 603 deaths in May 2020—a 92.6% and 87.8% increase compared to the 2015-2019 averages for those same months. The second peak in December 2020 corresponds to the time when the delta and omicron variants spread simultaneously, following the October rose garden super-spreader event, Thanksgiving, and end-of-year religious gatherings (Nakamura & Nirappil, 2020).

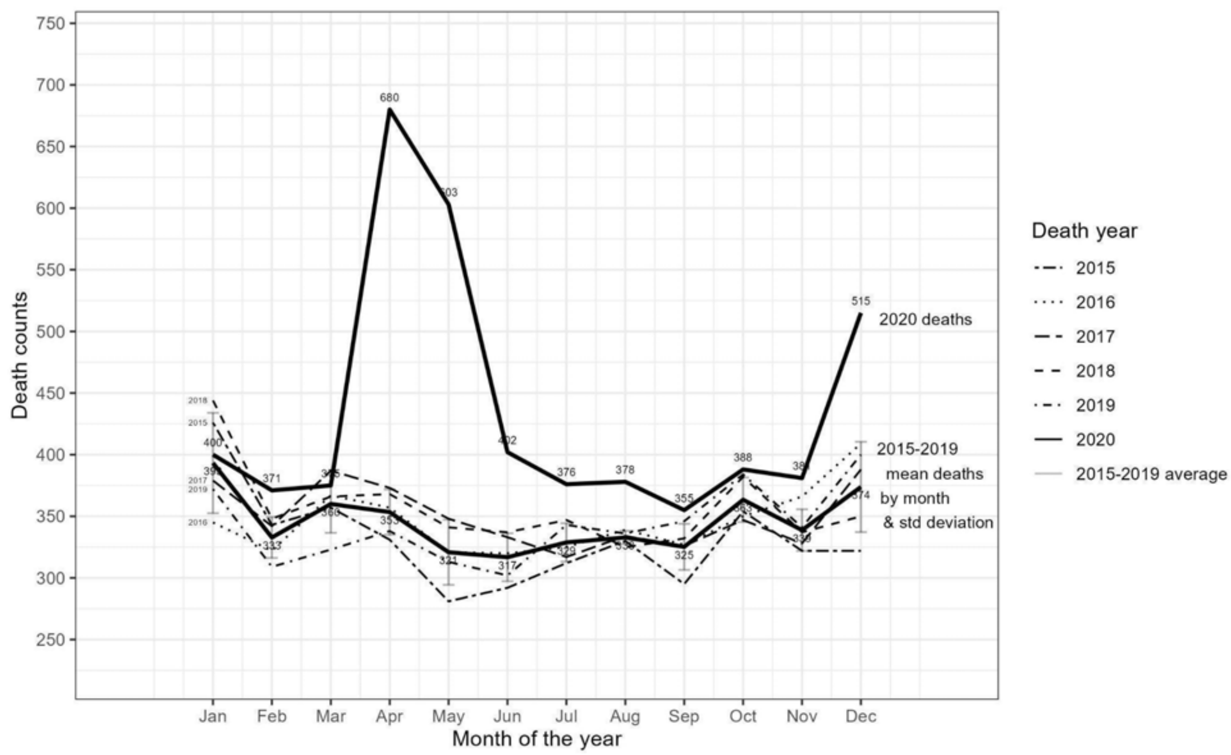

Figure 2: Monthly death counts in Washington, DC, in 2020 far outpaced previous years in April, May, and December.

As shown in Figure 3, the already large 2015-2019 mortality gap between the Non-Hispanic Black population and other racial groups increased in 2020 even further. Non-Hispanic Blacks represent the majority of deaths across all age groups, with 1,292 deaths per 100,000, six times the rate of the Non-Hispanic White population in 2020. Hispanic/Latinos have had the highest increase in mortality rates compared to all other groups, an almost twofold increase in 2020 compared to the five previous years. For context, DC's population is 44% Non-Hispanic Black, 37% Non-Hispanic White, 11% Hispanic/Latino, and 4% Asian (see Appendix A.3 for Census estimates). While the demographic distribution has been relatively constant, there have been small decreases in the Non-Hispanic Black population and slight increases in the Non-Hispanic White and Hispanic/Latino population in the district. Over the past ten years, the Non-Hispanic Black population in DC has declined by 5.9 %, while the Non-Hispanic White and Hispanic/Latino population has increased by 2.5% and 2.2%, respectively (B02001: RACE - Census Bureau Table).

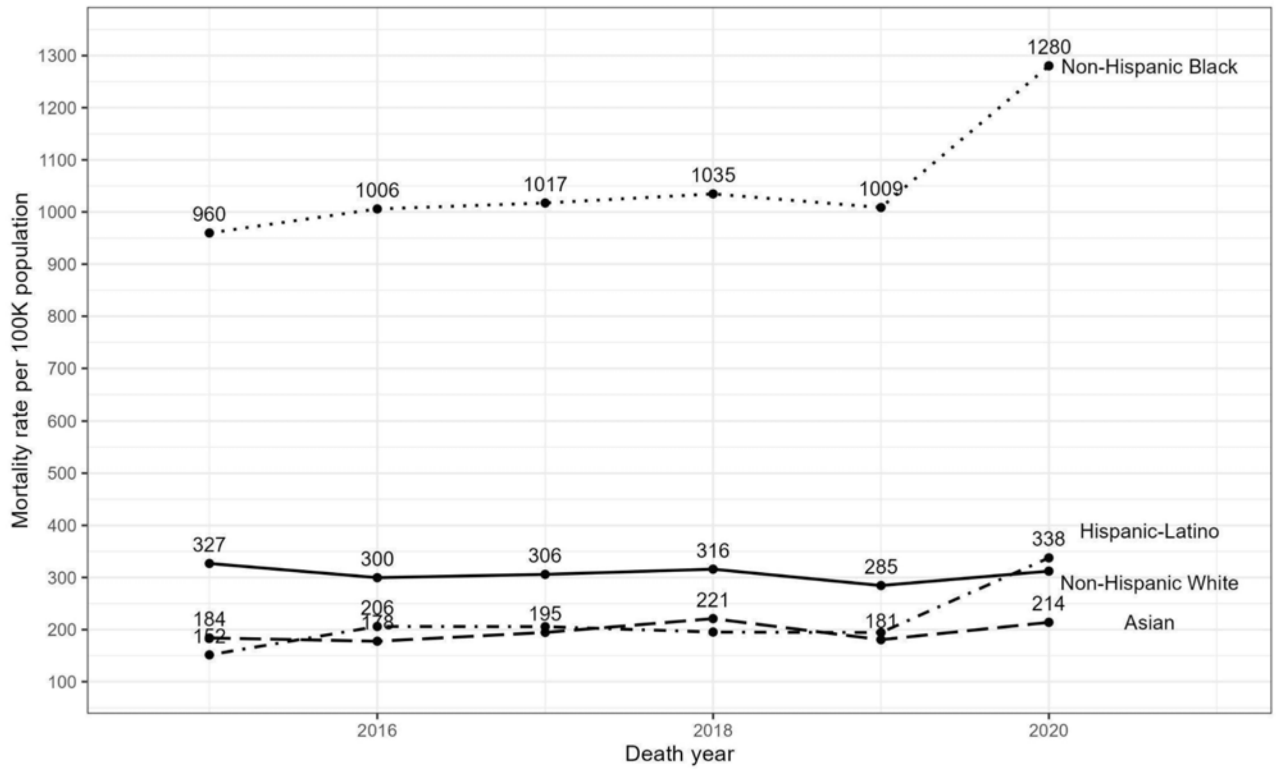

Figure 3: Racial disparities in DC mortality rates further amplified in 2020, growing higher for Blacks and proportionally increasing the most for Hispanic-Latinos.

Figure 4 shows that inequality in mortality rates has also widened along geographic dimensions, which reflects both the racial inequities just described and the residential segregation by race typical of unequal cities like Washington, DC. Washington, DC, is divided into eight wards for planning and administrative purposes, and these wards are distinguished from one another by the racial/ethnic groups concentrated therein (Appendix A.4). According to our results, the wards with the highest increases in mortality in 2020 relative to the 2015-2019 averages in decreasing order are wards 1 (45%), 7 (28%), 5 (25%), 4 (20%), 6 (18%), 8 (18%), 3 (<0.5%), 2 (<0.5%). This trend largely reflects the racial distribution across wards. Wards 1, 2, and 3 are predominantly Non-Hispanic White, while wards 4, 5, 6, 7, and 8 are predominantly Non-Hispanic Black. Wards 1 and 4 have a relatively large (>20%) and growing Hispanic/Latino population and are also the most demographically diverse (DC Health Matters, 2022).

Socio-economic factors reflect the differences in mortality rates: Wards 5, 6, 7, and 8 are considered low-income communities, and wards 7 and 8 have unemployment rates over 20%. In contrast, wards 2 and 3 have unemployment rates markedly below the national average (Arno, 2019). In terms of health outcomes, wards 5, 6, 7, and 8 historically have also had the highest prevalence of chronic conditions in the district (Garner et al., 2016), while the mortality rate has been highest historically in Wards 5, 7, and 8. As such, we find that increases in mortality during 2020 were most significant for those wards with the most Black and Hispanic residents and those with the lowest income and employment rates, corresponding with pre-existing trends in illness and mortality.

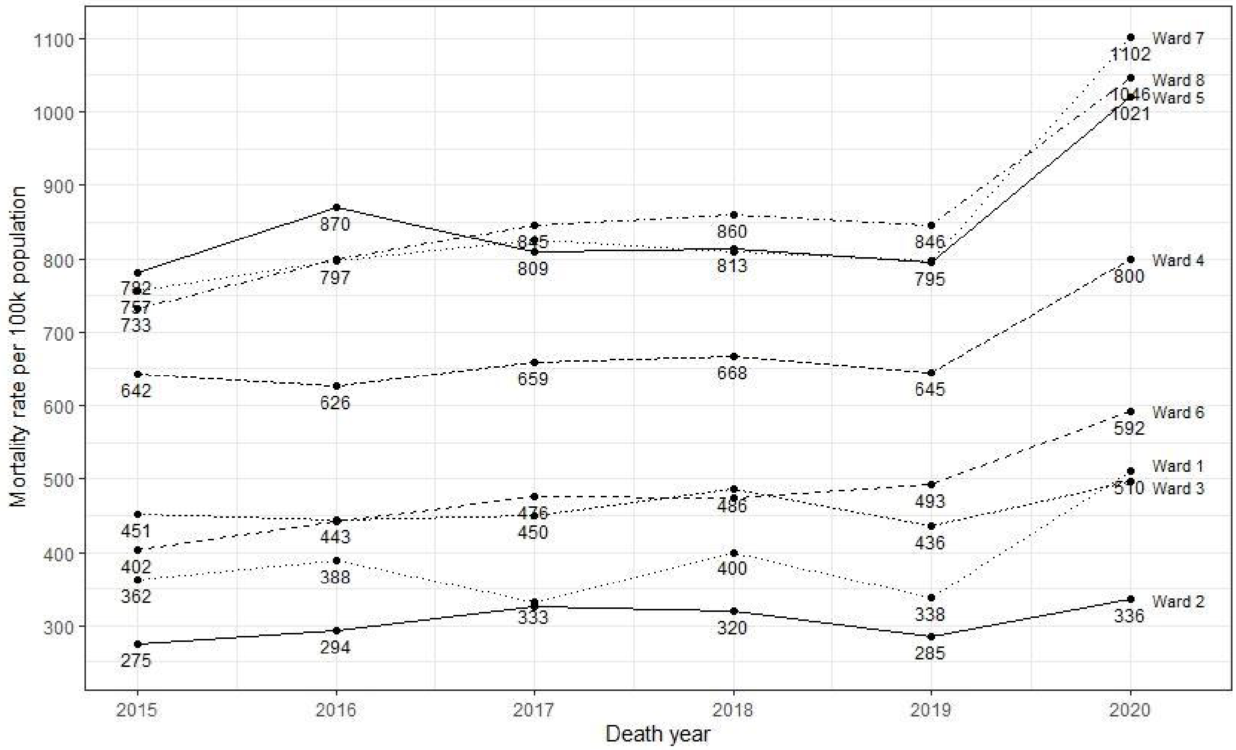

Figure 4: Increases in mortality rate in 2020 were greater for DC wards with more ethnic minorities and lower-income residents.

The mortality gap by sex also increased in 2020 (see Figure 5). The mortality rate of female residents was 650 deaths per 100K, compared to the male mortality rate of 825 deaths per 100K in 2020. The excess mortality for women in 2020 was 92.6 per 100K (corresponding to a 16.6% increase), and for men it was 174.3 per 100K (corresponding to a 26.8% increase).

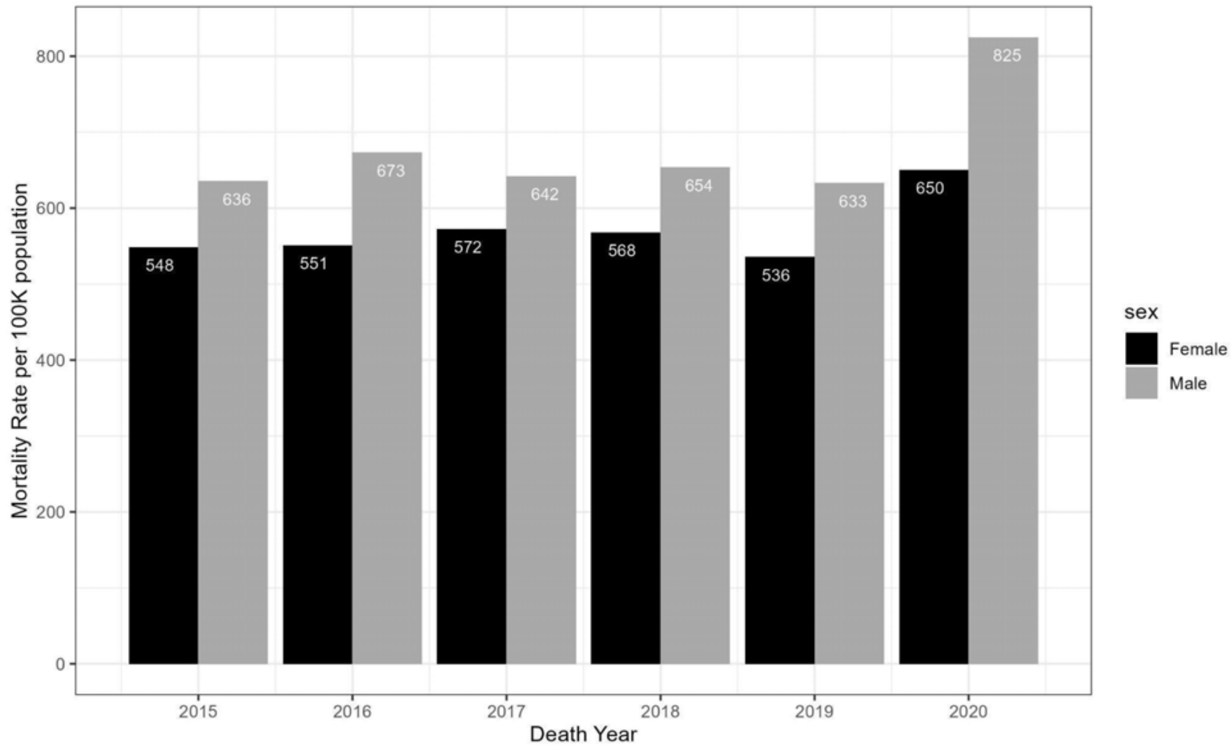

Figure 5: Mortality rate grew more for males than for females in 2020 in Washington, DC.

As argued above, COVID-19 deaths might be under-reported in official statistics because people who died had not been diagnosed or died of other comorbidities. As a result, COVID-19 was not listed as a cause of death on their death certificates. Our findings support this claim: among DC residents that died in the district in 2020, there were 676 (94.8 per 100K) deaths where COVID-19 was listed as a cause of death, leaving 314 unaccounted "excess" deaths. Changes in specific causes of death also reveal disparities by gender and race.

Figure 6 shows changes in the mortality rate between 2020 and the average of the previous five years for some of the most common conditions by race and sex. Deaths attributed to many of these causes grew most for Hispanics and Blacks, especially males in these groups. At the same time, cause-specific mortality rates for Whites either decreased or stayed the same, irrespective of gender. Some of the increases in mortality related to chronic conditions (e.g., diabetes, heart disease, COPD, and other respiratory diseases) in 2020 compared to previous years are also heavily concentrated in Blacks and (to a lesser extent) Hispanics, which may result from general avoidance of care due to the perceived risk of COVID-19 exposure (Beran et al., 2021; Ziedan et al., 2022) as well as the greater vulnerability of Blacks and Hispanics to chronic conditions relative to Whites. Decreases in the mortality rate for some of the most prevalent conditions might result from competing risks: if people die from COVID-19, they cannot die from other diseases, which reduces some cause-specific deaths such as cancer, diabetes, and heart disease.

Decreases in mortality for some causes of death like violent deaths and accidents and White males could also be the result of lockdowns, i.e., the shift from moving out and about in the world to settling into the more protected environment of one's home. In contrast, violent deaths, suicides, and accidents increased for Blacks and Hispanics. Communities disproportionately affected by poverty, systemic inequity, and structural racism incurred the heaviest loss of life due to rising gun violence. The Metropolitan Police Department reported a 34% increase in homicides in 2020 compared to the previous five-year average (District Crime Data at a Glance | mpdc) and nationwide, the CDC reported a 30% increase in the firearm homicide rate since the start of the pandemic (M. Kuehn, 2022). Blacks and Hispanics in the district are also essential and critical infrastructure workers. The U.S. Bureau of Labor Statistics reported increases in numerous types of construction jobs throughout 2020 (US Bureau of Labor Statistics), which might have contributed to the rise in accidents in groups with higher occupational exposure like Black and Hispanic males.

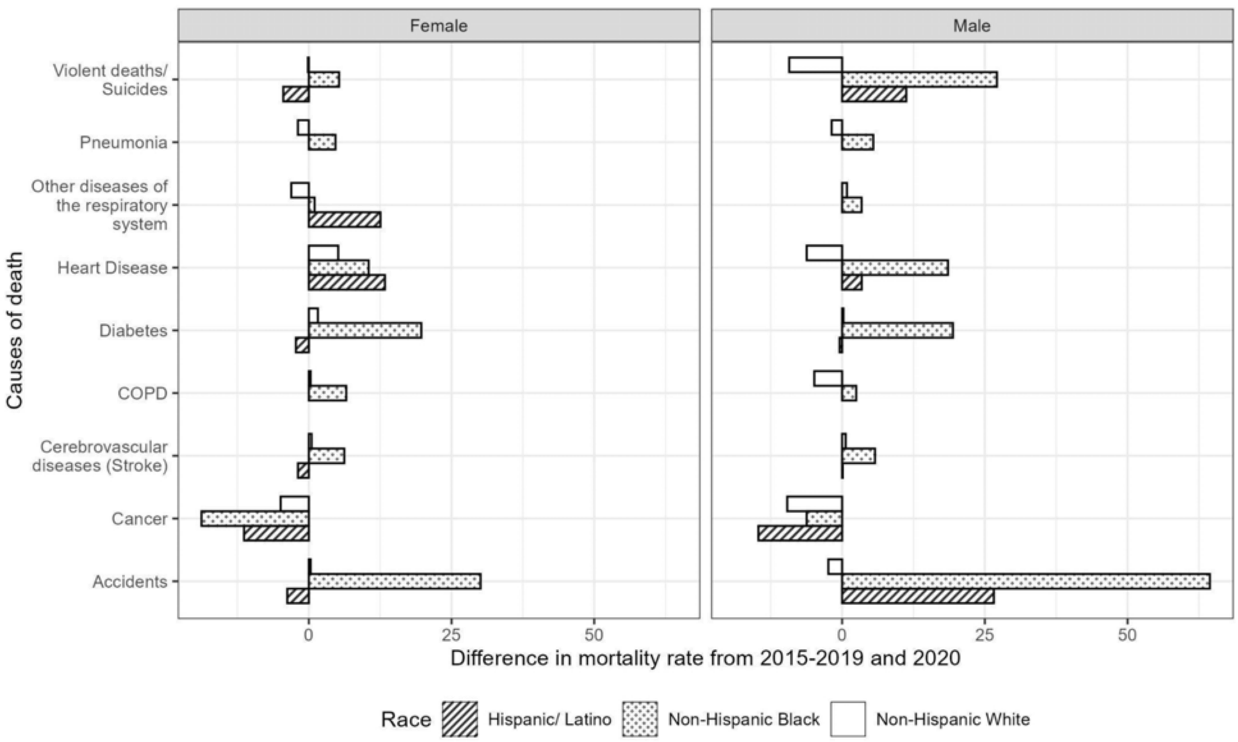

Figure 6: Cause-specific mortality rates grew for Blacks and Hispanics in 2020, especially for males, while rates remained flat for Whites.

Years of Life Lost (YLL)

Life expectancy for the total population decreased in 2020, with larger decreases for Hispanics and Blacks. In 2019, the average life expectancy in Washington, D.C., was 78, 0.8 years lower than the national average (Arias et al., 2022). Because there are no recent granular life tables for Washington DC, we use 2019 national life tables. The national average life expectancy for Hispanic women was 84.4, for White women was 81.3 years, and for Black women was 78.1 (Arias et al., 2022). The national average life expectancy for Hispanic men was 79.1, for White men was 76.3, and for Black men was 71.3.

Using DC-specific COVID prevalence rates, we estimate that in 2020 the life expectancy for White women was 81.2, for Hispanic women was 78.4, and for Black women was 72.8, representing 0.03, 6.01, and 5.31 YLL due to COVID-19, respectively. The estimated life expectancy for White men in 2020 was 76.3, for Hispanic men was 72.2, and for Black men was 65.2, representing 0.01, 6.88, and 6.15 YLL, respectively (Figure 7 and Appendix A.6). Compared to previous years, other contributors to premature mortality in 2020 were accidents, violent deaths and suicides, pneumonia, and other respiratory diseases (Appendix A.7).

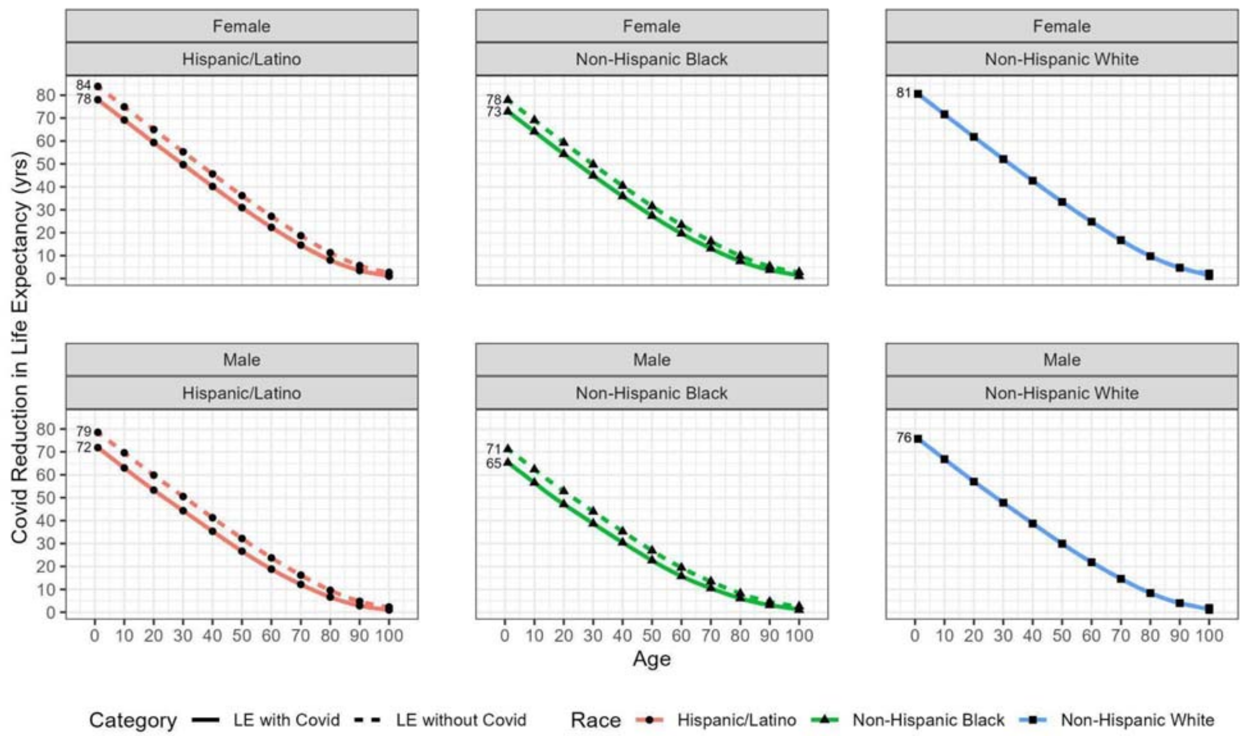

Figure 7: Black and Hispanic DC residents lost 6-7 expected years of life in 2020, while Whites lost none.

Conclusions

The widening of the life expectancy gap in a high-income but already unequal city like Washington DC during COVID-19 emphasizes the importance of micro-level research for supporting population health and grasping the ripples of major health disruptions like the COVID-19 pandemic. Examining mortality rates within population subgroups and using micro-level data (in our case, DC and its wards) allows us to understand how the pandemic has exacerbated health inequalities. Our analysis of mortality data from 2015 to 2020 shows that inequality in mortality rates by age, sex, race/ethnicity, and socioeconomic status (as denoted by the wards people live in) has widened dramatically.

We find that the inequality of life expectancy at birth in Washington, DC, widened in 2020. In DC, a person's race is highly correlated with income, and income is highly correlated with lifespan. Non-Hispanic Whites maintained roughly the same life expectancy in 2020 as pre-pandemic, whereas in 2020 alone Hispanic and Black males experienced a decrease in life expectancy greater than 8%, Hispanic females 7%, and Black females 6%. Indeed, national statistics can mask marked differences at the state/city level and within states/cities across groups. Large cities have traditionally been more unequal than small cities, and Washington DC has been consistently in the top 10 cities for inequality in the past five decades, together with New York, Chicago, San Francisco, and Los Angeles (Greenhalgh and Simmons-Duffin, 2022).

We show that in DC the burden of COVID-19 has been disproportionately higher on minorities, exacerbating existing longevity gaps. Our findings contrast with shrinking gaps in longevity along lines of race/ethnicity between 2000 and 2019: life expectancy for Black people, Hispanic, and Whites increased by 3.9 years, 2.7, and 1.7 years respectively (Dwyer-Lindgren et al., 2022). Whites made proportionately fewer gains in life expectancy because of the increased mortality among middle-aged white Americans over that same period, driven by the opioid epidemic (Case and Deaton, 2015). While most of the nation converged, DC maintained a large Black-White life expectancy gap for decades (Harper et al., 2014)—a gap that is now historically wide.

Particularly concerning are the YLL in the Hispanic/Latino and Black populations, which could have severe intergenerational consequences. The premature death of parents and caretakers has been shown in other contexts to contribute to social disadvantage across generations due to weathering (the chronic lack of emotional and socio-economic resources available to children following the death of a parent; Simons et al., 2016) and scarring (reduction in life satisfaction due to an adverse past experience like the death of a parent; Stewart, 2001). While COVID has played a role in shortening life expectancy, attributing the decline entirely to the virus would be misguided. Data from the Behavioral Risk Factor Surveillance System (BRFSS) has shown an ongoing increase in the prevalence of obesity and chronic conditions among Black and low-income individuals in the district (CDC, 2022b). As such, public health interventions such as nutrition education, incentivizing SNAP uptake as well as COVID-19 vaccines among those most disadvantaged could help reduce these disparities.

However, our results suggest that the pandemic be considered a catalyst of inequality in that its consequences are particularly burdensome on already vulnerable groups (i.e., people living in poverty, persons with chronic conditions, and older persons). Moreover, the racial and geographic concentration of mortality evidenced by our results means that the pandemic disproportionately affected groups that are most representative of essential workers, people unable to telecommute, or people living confined in close quarters (Gould, 2020). By devoting resources to prevent COVID-specific and -adjacent deaths, we can reduce these dangerous societal imbalances and promote equitable population health.

Limitations

Given the limitations of the 2020 census due to being conducted during a pandemic (US Census Bureau, 2021), the latest sex- and race-specific US life tables available for this analysis were from 2019. To the extent that sex and race distributions in DC might have changed from 2019 to

2020, our results for 2020 may be inaccurate. However, this is likely a small source of error given that the year-on-year demographic changes in DC are historically very small (US Census Bureau, a). Even so, small demographic changes accumulate over time; as such, using year-specific demographic estimates when available supports the overall accuracy of our analysis.

A second limitation is that our primary data source underestimates mortality rates in the city. While the denominator represents the count of residents in DC, the numerator represents only DC residents who have died in the district. Local departments of vital statistics do not have access to the death records of residents dying elsewhere. When the CDC aggregates the death counts from states and defines the total counts of deaths for each state and DC, we infer that approximately 14.4% of DC residents have died outside the state or overseas (Appendix A.5). Accounting for the demographic characteristics of residents that died outside DC would improve the accuracy of our estimates; unfortunately, such data are unavailable.

Finally, when calculating YLL, we use US lifetables rather than DC-specific life tables because CDC and state-specific life tables are not published at the level of granularity required (age, sex, and race). We also use the CDC-computed national relative risk of death by race. Only COVID-19 prevalence reflects district-specific values. For these reasons, our YLL estimates, though significant, represent conservative numbers.

Appendix

Appendix A.1. COVID-19 Prevalence Rate (%) by Age, Sex, and Race

Age	Non-Hispanic White male	Hispanic male	Non-Hispanic Black male	Non-Hispanic White female	Hispanic female	Non-Hispanic Black female
0-17	4.7%	16.1%	23.5%	4.9%	16.8%	24.4%
18-49	11.8%	19.0%	15.2%	12.2%	21.2%	22.7%
50-65	6%	11.7%	20.8%	3.7%	11.8%	22.3%
65+	5.5%	6.2%	17.9%	3.5%	5.2%	17.5%

Source: Author's calculations CDC and ACS 1-year estimates (B02001: RACE - Census Bureau Table)

Appendix A.2. Age-Adjusted Hazard Ratio of COVID Deaths by race

Race	**Age-adjusted risk of covid-19 death**
Black	1.7
Hispanic	1.9
American Indian or Alaskan Native	2.2
Asian	0.8
White	1 (reference category)

Source: (Hill and Artiga, 2022)

Appendix A.3. Total population estimates in Washington DC by year and racial breakdown

Year	Total population (% Margin of Error)	% Black (% Margin of Error)	% White (% Margin of Error)	% Hispanic (% Margin of Error)
2015	672,228 (± 0.1)	46.5% (± 0.3)	36.0 % (± 0.1)	10.6% (± 0.8)
2016	681,170 (± 0.1)	46.4% (± 0.3)	36.3% (± 0.1)	10.9% (± 0.7)
2017	693,972 (± 0.1)	45.3% (± 0.4)	36.5% (± 0.2)	11.0% (± 0.8)
2018	702,455 (± 0.3)	44.4% (± 0.4)	36.9% (± 0.1)	11.3% (± 0.7)
2019	705,749 (± 0.1)	44.1% (± 0.4)	37.3% (± 0.1)	11.3% (± 0.7)
2020	712,816 (± 0.1)	44.1% (± 0.4)*	37.3% (± 0.1)*	11.3% (± 0.7)*

Source: (B02001: RACE - Census Bureau Table)

*Note: As the experimental data tables released by the Census for 2020 (US Census Bureau, 2021) did not have a breakdown by race, we used the same race composition as 2020.

Margin of Error for Total population and Hispanic population estimates are calculated by aggregating the standard errors of the subgroups.

Standard Error = Margin of Error (90% confidence level)/1.645

Where Margin of Error = max (upper bound - estimate, estimate - lower bound)

$$SE\left(\widehat{X_1} + \widehat{X_2} + \cdots\right) \approx \sqrt{\left[SE\left(\widehat{X_1}\right)\right]^2 + \left[SE\left(\widehat{X_2}\right)\right]^2 + \cdots}$$

Where $SE\left(\widehat{X_1}\right), SE\left(\widehat{X_2}\right)$ etc. are standard errors of sample estimates and $SE\left(\widehat{X_1} + \widehat{X_2} + \cdots\right)$ is the approximate standard error of sum of these sample estimates.

Appendix A.4. Total population estimates by Ward

Ward	Population (2018 Census)	% Black (2018)	% White (2018)	% Hispanic (2018)	Median Income
1	85289	25.4%	46.9%	17.6%	110457
2	77923	7.9%	66.1%	12.9%	114649
3	84651	8.1%	70.4%	9.6%	129681
4	90300	48.4%	23.6%	22.5%	96245
5	92094	61.3%	22.5%	10.4%	77367
6	101882	27.7%	56.3%	7.8%	117752
7	84271	90.2%	2.7%	4.0%	48474
8	85564	86.0%	5.9%	4.1%	37963

Source: (Open Data DC)

Note: Data at the ward level is not available after 2018.Median Income in 2020 inflation-adjusted dollars.

Note: The three racial groups account for approximately 93% of the population. The remainder represents the following groups as described by the ACS: Asians, American Indian and Alaska Native, Native Hawaiian and Other Pacific Islanders, Some other race.

Appendix A.5. DC Department of Vital Statistics versus CDC mortality counts

Year	DC Department of Vital Statistics mortality	CDC mortality
2015	3965	4721
2016	4148	4881
2017	4202	4861

2018	4277	4918
2019	4107	4805
2020	5224	6098

Sources: DC Department of Vital Statistics (CDC, 2022a) and CDC WONDER (CDC Wonder)

Notes: 2020 values are still provisory for the CDC. The CDC numbers include DC residents who die in other states which translated into higher death numbers

Appendix A.6: Life Expectancy at birth with and without Covid-19 by race and sex

		Life Expectancy at birth	
Race	Sex	Without Covid-19	With Covid-19
Hispanic	Female	84.4	78.4
Hispanic	Male	79.1	72.2
Non-Hispanic Black	Female	78.1	72.8
Non-Hispanic Black	Male	71.3	65.2
Non-Hispanic White	Female	81.3	81.2
Non-Hispanic White	Male	76.3	76.3

Appendix A.7. Average age at death for selected causes of death

Cause of Death	**2015-2019**	**2020**
Accidents	55.5	54.8
Cancer	70.5	71.7
COPD	76.8	78.0
Covid	NA	72.8

Diabetes	69.6	68.3
Heart Disease	75.4	76.0
Other Respiratory System Diseases	73.9	70.5
Pneumonia	77.0	73.9
Stroke	79.3	80.2
Violent deaths/Suicides	35.9	35.6

References

Arias, E., Xu, J., Division of Vital Statistics, 2022. United States Life Tables, 2019 59.
Arno, A., 2019. Health Equity Summary Report: District of Columbia 2018.
B02001: RACE - Census Bureau Table [WWW Document], n.d. URL https://data.census.gov/cedsci/table?q=race&g=0400000US11&d=ACS%201-Year%20Estimates%20Detailed%20Tables&tid=ACSDT1Y2019.B02001 (accessed 11.5.22).
Baker, R.E., Park, S.W., Yang, W., Vecchi, G.A., Metcalf, C.J.E., Grenfell, B.T., 2020. The impact of COVID-19 nonpharmaceutical interventions on the future dynamics of endemic infections. Proc. Natl. Acad. Sci. 117, 30547–30553. https://doi.org/10.1073/pnas.2013182117
Beran, D., Aebischer Perone, S., Castellsague Perolini, M., Chappuis, F., Chopard, P., Haller, D.M., Jacquerioz Bausch, F., Maisonneuve, H., Perone, N., Gastaldi, G., 2021. Beyond the virus: Ensuring continuity of care for people with diabetes during COVID-19. Prim. Care Diabetes 15, 16–17. https://doi.org/10.1016/j.pcd.2020.05.014
Case, A., Deaton, A., 2015. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. Proc. Natl. Acad. Sci. 112, 15078–15083. https://doi.org/10.1073/pnas.1518393112
CDC, 2022a. NVSS [WWW Document]. URL https://www.cdc.gov/nchs/nvss/about_nvss.htm (accessed 8.15.22).
CDC, 2022b. CDC - BRFSS - Survey Data & Documentation [WWW Document]. URL https://www.cdc.gov/brfss/data_documentation/index.htm (accessed 11.14.22).
CDC, 2021. COVID-19 Case Surveillance Public Use Data with Geography | Data | Centers for Disease Control and Prevention [WWW Document]. URL https://data.cdc.gov/Case-Surveillance/COVID-19-Case-Surveillance-Public-Use-Data-with-Ge/n8mc-b4w4 (accessed 9.14.22).
CDC, 2020. COVID Data Tracker [WWW Document]. Cent. Dis. Control Prev. URL https://covid.cdc.gov/covid-data-tracker (accessed 8.21.22).

CDC Wonder, n.d. Underlying Cause of Death, 1999-2020 Request [WWW Document]. URL https://wonder.cdc.gov/ucd-icd10.html (accessed 11.5.22).

Davies, N.G., Barnard, R.C., Jarvis, C.I., Kucharski, A.J., Munday, J., Pearson, C.A.B., Russell, T.W., Tully, D.C., Abbott, S., Gimma, A., Waites, W., Wong, K.L., Zandvoort, K. van, Group, C.C.-19 W., Eggo, R.M., Funk, S., Jit, M., Atkins, K.E., Edmunds, W.J., 2020. Estimated transmissibility and severity of novel SARS-CoV-2 Variant of Concern 202012/01 in England. https://doi.org/10.1101/2020.12.24.20248822

DC Data | op [WWW Document], n.d. URL https://planning.dc.gov/page/dc-data (accessed 8.15.22).

DC Health Matters, 2022. DC Health Matters□:: Demographics□:: Ward□:: Ward 1 [WWW Document]. URL https://www.dchealthmatters.org/demographicdata?id=131488 (accessed 8.25.22).

District Crime Data at a Glance | mpdc [WWW Document], 2022. URL https://mpdc.dc.gov/page/district-crime-data-glance (accessed 11.14.22).

DoH, 2020a. DC Department of Health Confirms First Coronavirus Case | coronavirus [WWW Document]. URL https://coronavirus.dc.gov/release/dc-department-health-confirms-first-coronavirus-case (accessed 8.24.22).

DoH, 2020b. DC Health Announces First COVID-19 Related Death | coronavirus [WWW Document]. URL https://coronavirus.dc.gov/release/dc-health-announces-first-covid-19-related-death (accessed 8.24.22).

Dwyer-Lindgren, L., Kendrick, P., Kelly, Y.O., Sylte, D.O., Schmidt, C., Blacker, B.F., Daoud, F., Abdi, A.A., Baumann, M., Mouhanna, F., Kahn, E., Hay, S.I., Mensah, G.A., Nápoles, A.M., Pérez-Stable, E.J., Shiels, M., Freedman, N., Arias, E., George, S.A., Murray, D.M., Phillips, J.W., Spittel, M.L., Murray, C.J., Mokdad, A.H., 2022. Life expectancy by county, race, and ethnicity in the USA, 2000–19: a systematic analysis of health disparities. The Lancet 400, 25–38. https://doi.org/10.1016/S0140-6736(22)00876-5

Garner, T., Behavioral Risk Factor Surveillance System, Center for Policy, Planning and Evaluation, 2016. BRFSS Annual Report 2014 | doh [WWW Document]. URL https://dchealth.dc.gov/node/1190347 (accessed 9.14.22).

Gould, E., 2020. Older workers can't work from home and are at a higher risk for COVID-19 [WWW Document]. Econ. Policy Inst. URL https://www.epi.org/blog/older-workers-cant-work-from-home-and-at-high-risk-for-covid-19/ (accessed 11.14.22).

Gray, A., Clarke, P., Wolstenholme, J., Wordsworth, S., 2010. Applied Methods of Cost-effectiveness Analysis in Healthcare — Health Economics Research Centre (HERC) [WWW Document]. URL https://www.herc.ox.ac.uk/downloads/applied-methods-of-cost-effectiveness-analysis-in-healthcare (accessed 8.21.22).

Greenhalgh, J., Simmons-Duffin, S., 2022. Life expectancy in the U.S. continues to drop, driven by COVID-19. NPR.

Harper, S., MacLehose, R.F., Kaufman, J.S., 2014. Trends in the black-white life expectancy gap among US states, 1990-2009. Health Aff. Proj. Hope 33, 1375–1382. https://doi.org/10.1377/hlthaff.2013.1273

Hawkins, D., Berger, M., Iati, M., Kornfield, M., Shammas, B., 2020. Trump declares coronavirus outbreak a national emergency [WWW Document]. Wash. Post. URL https://www.washingtonpost.com/world/2020/03/13/coronavirus-latest-news/ (accessed 8.21.22).

Hill, L., Artiga, S., 2022. COVID-19 Cases and Deaths by Race/Ethnicity: Current Data and Changes Over Time. KFF. URL https://www.kff.org/coronavirus-covid-19/issue-brief/covid-19-cases-and-deaths-by-race-ethnicity-current-data-and-changes-over-time/ (accessed 11.5.22).

Katz, J., 2020. Deaths in New York City Are More Than Double the Usual Total - The New York Times [WWW Document]. URL https://www.nytimes.com/interactive/2020/04/10/upshot/coronavirus-deaths-new-york-city.html (accessed 10.20.22).

Krueger, P.M., Jutte, D.P., Franzini, L., Elo, I., Hayward, M.D., 2015. Family structure and multiple domains of child well-being in the United States: a cross-sectional study. Popul. Health Metr. 13, 6. https://doi.org/10.1186/s12963-015-0038-0

M. Kuehn, B., 2022. Rising US Firearm Deaths During Pandemic Linked to Poverty | Firearms | JAMA | JAMA Network [WWW Document]. URL https://jamanetwork.com/journals/jama/fullarticle/2793243 (accessed 11.14.22).

McKnight-Eily, L.R., 2021. Racial and Ethnic Disparities in the Prevalence of Stress and Worry, Mental Health Conditions, and Increased Substance Use Among Adults During the COVID-19 Pandemic — United States, April and May 2020. MMWR Morb. Mortal. Wkly. Rep. 70. https://doi.org/10.15585/mmwr.mm7005a3

Nakamura, D., Nirappil, F., 2020. Rose Garden event suspected of virus outbreak alarms D.C. officials. Wash. Post.

Open Data DC [WWW Document], n.d. URL https://opendata.dc.gov/ (accessed 8.15.22).

Pharoah, P.D., Hollingworth, W., 1996. Cost effectiveness of lowering cholesterol concentration with statins in patients with and without pre-existing coronary heart disease: life table method applied to health authority population. BMJ 312, 1443–1448. https://doi.org/10.1136/bmj.312.7044.1443

Planning Area Data | op [WWW Document], n.d. URL https://planning.dc.gov/page/planning-area-data (accessed 8.15.22).

Portnoy, J., Nirappil, F., Simon, D., 2020. D.C. declares state of emergency as concerts, parades, church services are canceled. Wash. Post.

Poulton, R., Caspi, A., Milne, B.J., Thomson, W.M., Taylor, A., Sears, M.R., Moffitt, T.E., 2002. Association between children's experience of socioeconomic disadvantage and adult health: a life-course study. Lancet 360, 1640–1645. https://doi.org/10.1016/S0140-6736(02)11602-3

Roberts, M., Reither, E.N., Lim, S., 2020. Contributors to the black-white life expectancy gap in Washington D.C. Sci. Rep. 10, 13416. https://doi.org/10.1038/s41598-020-70046-6

Simons, R.L., Lei, M.K., Beach, S.R.H., Philibert, R.A., Cutrona, C.E., Gibbons, F.X., Barr, A., 2016. Economic Hardship and Biological Weathering: The Epigenetics of Aging in a U.S. Sample of Black Women. Soc. Sci. Med. 1982 150, 192–200. https://doi.org/10.1016/j.socscimed.2015.12.001

Stein, P., Natanson, H., 2020. All public schools systems in the Washington region are set to close amid coronavirus fears - The Washington Post [WWW Document]. URL https://www.washingtonpost.com/local/education/dc-public-schools-will-close-beginning-monday-as-officials-attempt-to-contain-virus-outbreak/2020/03/13/3d992d10-64dc-11ea-845d-e35b0234b136_story.html (accessed 9.14.22).

Stewart, J.M., 2001. The impact of health status on the duration of unemployment spells and the implications for studies of the impact of unemployment on health status. J. Health Econ. 20, 781–796. https://doi.org/10.1016/s0167-6296(01)00087-x

Truman, B.I., 2022. Provisional COVID-19 Age-Adjusted Death Rates, by Race and Ethnicity — United States, 2020–2021. MMWR Morb. Mortal. Wkly. Rep. 71. https://doi.org/10.15585/mmwr.mm7117e2

US Bureau of Labor Statistics, n.d. Washington-Arlington-Alexandria, DC-VA-MD-WV - May 2021 OEWS Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates [WWW Document]. URL https://www.bls.gov/oes/current/oes_47900.htm#47-0000 (accessed 11.14.22).

US Census Bureau, 2021. 2020 ACS 1-Year Experimental Data Tables [WWW Document]. Census.gov. URL https://www.census.gov/programs-surveys/acs/data/experimental-data/1-year.html (accessed 8.15.22).

US Census Bureau, n.d. American Community Survey 1-Year Data (2005-2020) [WWW Document]. Census.gov. URL https://www.census.gov/data/developers/data-sets/acs-1year.html (accessed 9.14.22a).

US Census Bureau, n.d. Code Lists, Definitions, and Accuracy [WWW Document]. Census.gov. URL https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html (accessed 11.14.22b).

Ziedan, E., Simon, K.I., Wing, C., 2022. Mortality Effects of Healthcare Supply Shocks: Evidence Using Linked Deaths and Electronic Health Records. Working Paper Series. https://doi.org/10.3386/w30553