Shifting Mortality Dynamics in the United States During the COVID-19 Pandemic as Measured by Years of Life Lost

Background: During March 2020 to September 2022, more than 1 million COVID-19-involved deaths occurred in the United States (1). As described by Shiels and colleagues (2), COVID-19 deaths during March to December 2020 and January to October 2021 were similar. However, COVID-19-involved deaths increased among younger persons and decreased among older adults in 2021 versus 2020 (2), reflecting excess premature mortality from COVID-19.

Objective: We endeavored to quantify this downward age shift in COVID-19-involved deaths, which required an age-weighted metric. Unlike the mortality metric, the measure of years of life lost (YLL) (3) offers an indicator of premature mortality based on the estimated number of years a person would have lived if they had not died prematurely. We therefore sought to estimate YLL associated with leading causes of U.S. death during matched 10-month intervals in 2020 and 2021.

Methods and Findings: Mortality data from March to December in 2020 and 2021 were obtained from CDC WONDER (Centers for Disease Control and Prevention Wide-ranging ONline Data for Epidemiologic Research), an integrated system of public-use data sets spanning public health topics (1). Age-specific standard life expectancies were obtained from the 2017 World Population Prospects and World Health Organization Global Health Estimate, providing frontier-period life expectancy projections for the year 2050 to represent lifespans thought to be achieved by a substantial number of people alive at the time of this analysis (3, 4). Absolute YLL due to cause of death c, in population of age a during interval t were defined as YLL (c, a, t) = D(c, a, t) × SLE(a), where D represents the number of deaths and SLE represents standard life expectancy (3). For the 15 leading causes of death, YLL were estimated, comparing March to December 2020 with March to December 2021 to

| Table. Leading Causes of U.S. Death and Associated YLL, March to December in 2020 and 2021 |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Cause†                                    | Deaths,‡ n | Median Age at Time of Death§ (IQR), y | YLL¶ n | YLL per Death, n |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Heart disease                                | 579 424        | 79 (67-88)      | 10 626 800      | 10 665 405      | 18.3            | 18.6            |
| Cancer                                       | 501 105        | 73 (64-81)      | 11 136 822      | 11 230 911      | 22.2            | 22.1            |
| COVID-19                                     | 350 702        | 78 (69-80)      | 6 596 445       | 7 086 933       | 18.8            | 25.5            |
| Unintentional injuries†                      | 171 626        | 51 (35-70)      | 6 946 356       | 7 698 205       | 40.6            | 40.4            |
| Stroke                                       | 133 227        | 82 (72-89)      | 2 157 941       | 2 209 510       | 16.2            | 16.4            |
| Chronic lower respiratory diseases           | 122 666        | 77 (69-84)      | 2 244 165       | 2 184 391       | 18.3            | 18.4            |
| Alzheimer disease                            | 112 613        | 87 (81-92)      | 1 170 588       | 1 023 460       | 10.4            | 10.6            |
| Diabetes                                     | 86 111         | 72 (62-81)      | 1 957 615       | 1 940 428       | 22.7            | 23.0            |
| Chronic liver disease and cirrhosis          | 43 784         | 60 (52-69)      | 1 437 730       | 1 557 295       | 32.8            | 33.0            |
| Kidney disease                               | 43 041         | 78 (68-87)      | 800 920         | 845 432         | 18.6            | 18.9            |
| Influenza and pneumonia                      | 40 599         | 79 (68-87)      | 750 345         | 641 003         | 18.5            | 18.8            |
| Suicide                                      | 38 575         | 45 (30-61)      | 1 775 810       | 1 888 570       | 46.0            | 46.2            |
| Hypertension                                 | 35 102         | 80 (68-89)      | 602 759         | 610 979         | 17.2            | 17.5            |
| Parkinson disease                            | 33 762         | 82 (77-88)      | 458 537         | 435 432         | 13.6            | 13.7            |
| Septicemia                                   | 32 897         | 74 (64-83)      | 703 839         | 737 405         | 21.4            | 21.6            |
| Totals                                       | 2 325 254      | 2 251 581       | -               | -               | -               | -               |

IQR = interquartile range; YLL = years of life lost.
† Causes of death are ordered by the leading causes of death in 2020. Leading causes of death and associated International Classification of Diseases, Tenth Revision (ICD-10) codes follow: heart disease (100-109, 111, 113, I20-I51); cancer (C00-C97); COVID-19 (U07.1); unintentional injuries (V01-X59, Y85-Y86); stroke or cerebrovascular diseases (I60-I69); chronic lower respiratory diseases (J40-J47); Alzheimer disease (G30); diabetes mellitus (E10-E14); chronic liver disease and cirrhosis (K70, K73-K74); nephritis, nephrotic syndrome, and nephrosis (N00-N07, N17-N19, N25-N27); influenza and pneumonia (J09-J18); intentional self-harm or suicide (U03, X60-X64, Y87.0); essential hypertension and hypertensive renal disease (*110, 112, 115); Parkinson disease (G20-G21); and septicemia (A40-A41).
‡ Mortality data by age and sex were obtained from CDC WONDER (Centers for Disease Control and Prevention Wide-ranging ONline Data for Epidemiologic Research) through the National Center for Health Statistics (1).
§ The CDC WONDER data reported decedents below the age of 1 year, who were classified as having been 0 years old, and decedents as 100 years or older, who were classified as having been 100 years old.
¶ YLL due to each cause of death c, in a population of age a during the interval t was defined by the formula as described in Martinez and colleagues (3): YLL(c, a, t) = D(c, a, t) × SLE(a) where D(c, a, t) is the number of deaths due to the cause c and age a during the interval t and SLE(a) is the standard life expectancy at age a. The SLE, which represents the lifespan of a person at a given age who is not exposed to avoidable health risks or severe injuries and receives appropriate health services, was obtained from the 2017 World Population Prospects and World Health Organization Global Health Estimate, providing frontier-period life expectancy for the year 2050 to represent lifespans thought achieved by a substantial number of people alive at the time of this study (4). Projections to the year 2050 were used considering that the use of normative loss of years of life in terms of currently observed death rates does not account for the proportion of current deaths that will be readily preventable or avertable for a substantial number of people alive at the time of this study. For SLEs provided for people aged 100 through 105 years, given that CDC WONDER data classified decedents as 100 years or older in 1 category, the mean SLE for people aged 100 through 105 years was used for this group.
¶† Deaths due to unintentional injuries include transportation motor vehicle crashes, unintentional drug overdoses and alcohol-related deaths, and other unintentional injuries leading to deaths.

© 2022 American College of Physicians

141

Letters
Changes in leading causes of death and associated YLL, March to December in 2020 and 2021.

For all panels, outcomes are compared in March to December 2021 versus the reference interval March to December 2020. Deaths due to unintentional injuries include transportation motor vehicle crashes, unintentional drug overdoses and alcohol-related deaths, and other unintentional injuries leading to deaths. CLRD = chronic lower respiratory disease; YLL = years of life lost. Top. Changes in leading causes of death. Middle. Changes in YLL. Bottom. Changes in YLL per death. Bars indicate the percentage difference between study intervals for each outcome.
minimize the effects of seasonal variation in mortality on the comparator intervals. Data were analyzed in Python version 3.7.8. Institutional review board approval was exempted per the Common Rule (45 CFR §46) because the study used publicly available, deidentified data.

The 15 leading causes of U.S. death were the same in both 10-month intervals and accounted for approximately 80% of deaths. Unsuppressed data were available for 99.95% of deaths.

The YLL associated with most of the leading causes of U.S. death were stable across intervals (Table). Three of the four causes of death that exhibited larger than 10% changes in deaths across the study intervals had concordant changes in YLL. Specifically, YLL due to unintentional injuries increased by 10.5%, comparable to the 11.0% increase in unintentional injury deaths. Large and similar decreases in YLL and deaths were observed for influenza and pneumonia (YLL, –14.6%; deaths, –16.0%) and Alzheimer disease (YLL, –12.6; deaths, –14.2%). In contrast, despite 20.8% fewer COVID-19 deaths during March to December 2021 than during March to December 2020, YLL due to COVID-19 increased by 7.4% as the age distribution of decedents shifted downward (that is, to relatively younger persons); the median (interquartile range) age of COVID-19-involved deaths decreased from 78 years (68 to 87 years) to 69 years (59 to 80 years). Accordingly, YLL per COVID-19 death increased by 35.7% (Figure); YLL per death did not change by more than 2.2% for any other cause.

Discussion: In the United States, 20.8% more COVID-19-involved deaths were reported in the first 10 months of the pandemic compared with a seasonally matched interval in the pandemic’s second year. Despite this, 7.4% more years of life were lost in the second pandemic year during that interval due to a 35.7% increase in YLL per COVID-19 death. Further investigation should determine the extent to which this downward age shift in COVID-19 mortality is attributable to high early-pandemic COVID-19 death rates among older adults (for example, involving nursing homes and long-term care facilities), relatively higher vaccine coverage and adherence with nonpharmaceutical interventions among older versus younger adults later in the pandemic, age-related risk differences associated with coronavirus variant viruses, or other mechanisms. Understanding this shift in COVID-19 mortality dynamics could inform prevention and treatment approaches, public policy development, and community measures to minimize future effects of COVID-19.

Analysis of YLL reveals additional changes among the leading causes of U.S. death. The YLL and deaths due to Alzheimer and Parkinson diseases both decreased, perhaps due to early-pandemic increased incidence of each due to misattribution of COVID-19 deaths when there was limited testing and considerable COVID-19-related missed medical care. Conversely, YLL and deaths due to unintentional injuries increased considerably, owing in part to record-high drug overdose deaths, up 15% (nearly 14 000 deaths) in 2021 compared with 2020 (5).

Strengths of this analysis include use of national mortality data and age-specific projected standard life expectancies to estimate YLL. Limitations include provisional 2021 deaths, which are subject to reporting lags. Importantly, the YLL metric compares a person’s life expectancy with their age at the time of their death and should not be used as a measure of a person’s potential contributions to society.

In conclusion, a shift in COVID-19 mortality to relatively younger people in the second pandemic year contributed to markedly elevated YLL from this increasingly preventable cause of death.

Mark É. Czei, PhD
Francis Weld Peabody Society, Harvard Medical School, Boston, Massachusetts

Charles A. Czei, PhD, MD
Departments of Medicine and Neurology, Brigham and Women’s Hospital, Harvard Medical School, Boston, Massachusetts

Financial Support: No direct funding supported this analysis. Dr. C.A. Czei is the incumbent of an endowed professorship provided to Harvard University by Cephalon.

Disclosures: Disclosures can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M22-2226.

Reproducible Research Statement: Study protocol: Not applicable.
Statistical code: Available to interested readers by contacting Dr. Mark É. Czei at mark.czei@fulbrightmail.org. Data set: Mortality data are available from CDC WONDER (https://wonder.cdc.gov). Standard life expectancy data are available from the United Nations 2017 Revision of the World Population Prospects (www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html).

Corresponding Author: Mark É. Czei, PhD, Francis Weld Peabody Society, Harvard Medical School, 25 Shattuck Street, Boston, MA 02115; e-mail, mark.czei@fulbrightmail.org or mczei@hms.harvard.edu.

Previous Posting: A prior version of this manuscript was posted as a preprint on medRxiv on 22 July 2022. doi:10.1101/2022.07.22.22277899

This article was published at Annals.org on 29 November 2022. doi:10.7326/M22-2226

References
1. Centers for Disease Control and Prevention. CDC WONDER: Accessed at https://wonder.cdc.gov on 7 July 2022.
2. Shiel MS, Haque AT, Berreingto de Gonzalez A, et al. Leading causes of death in the US during the COVID-19 pandemic, March 2020 to October 2021. JAMA Intern Med. 2022;182:883-6. [PMID: 35788262] doi:10.1001/jamainternmed.2022.2476
3. Martinez R, Soliz P, Caixeta R, et al. Reflection on modern methods: years of life lost due to premature mortality—a versatile and comprehensive measure for monitoring non-communicable disease mortality. Int J Epidemiol. 2019;48:1367-76. [PMID: 30629192] doi:10.1093/ije/dyy254
4. United Nations Department of Economic and Social Affairs. World Population Prospects: The 2017 Revision. United Nations; 2017. Accessed at www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html on 22 October 2022.
5. National Center for Health Statistics. U.S. Overdose Deaths In 2021 Increased Half as Much as in 2020 - But Are Still Up 15%. 11 May 2022. Accessed at www.cdc.gov/nchs/pressroom/nchs_press_releases/2022/202205.htm on 22 October 2022.