Background: Excess death estimates quantify the full impact of the coronavirus disease 2019 (COVID-19) pandemic. Widely reported U.S. excess death estimates have not accounted for recent population changes, especially increases in the population older than 65 years.

Objective: To estimate excess deaths in the United States in 2020, after accounting for population changes.

Design: Surveillance study.

Setting: United States, March to August 2020.

Participants: All decedents.

Measurements: Age-specific excess deaths in the United States from 1 March to 31 August 2020 compared with 2015 to 2019 were estimated, after changes in population size and age were taken into account, by using Centers for Disease Control and Prevention provisional death data and U.S. Census Bureau population estimates. Cause-specific excess deaths were estimated by month and age.

Results: From March through August 2020, 1,671,400 deaths were registered in the United States, including 173,300 COVID-19 deaths. An average of 1,370,000 deaths were reported over the same months during 2015 to 2019, for a crude excess of 301,400 deaths (128,100 non-COVID-19 deaths). However, the 2020 U.S. population includes 5.04 million more persons aged 65 years and older than the average population in 2015 to 2019 (a 10% increase). After population changes were taken into account, an estimated 217,900 excess deaths occurred from March through August 2020 (173,300 COVID-19 and 44,600 non-COVID-19 deaths). Most excess non-COVID-19 deaths occurred in March and August, and 34,900 (78%) were in persons aged 25 to 64 years. Deaths from diabetes, Alzheimer disease, and heart disease caused the most non-COVID-19 excess deaths.

Limitation: Provisional death data are underestimated because of reporting delays.

Conclusion: The COVID-19 pandemic resulted in an estimated 218,000 excess deaths in the United States during March and August 2020, and 80% of those deaths had COVID-19 as the underlying cause. Accounting for population changes substantially reduced the excess non-COVID-19 death estimates, providing important information for guiding future clinical and public health interventions.

Primary Funding Source: National Cancer Institute.

Additional data released by the CDC on March and August 2020 also can help guide clinical and public health practice in preventing non-COVID-19 deaths during the pandemic.

Studies of excess deaths in the United States (1-5), as well as analyses published by the media, have calculated the absolute excess number of deaths by using data from the Centers for Disease Control and Prevention (CDC) on total deaths, by week, in 2020 compared with deaths during the same week in recent years (2014/2015 to 2019). These estimates did not account for population changes during the comparison period, although the U.S. population is in the midst of a major transition driven by aging of the Baby Boomers (that is, the 1945 to 1965 birth cohorts) (6). Of importance, the population aged 65 years and older grew by a third in the past decade.

Here, we use additional data released by the CDC on age at death to show the importance of accounting for the shifting age structure and population size when estimating the total number of excess deaths in the United States during the COVID-19 pandemic. We then estimated the number of excess deaths by age, by month, and for some specific causes during March to August 2020, adjusting for age and population.

Methods: Provisional data for 2019 and 2020 released on 12 November 2020 (7), as well as complete data for 2015 to 2018 (8) on deaths by month, age group, and cause of death, were obtained from the CDC National Center for Health Statistics (NCHS) for 1 March (first full month of COVID-19 deaths in the United States) to 31 August. Provisional death counts are based on mortality data reported to the National Vital Statistics System by the state vital registration office in all 50 states and the District of Columbia (9). Population estimates for 2015 to 2020 by age, month, and year were obtained from the U.S. Census Bureau (10). The Census Bureau publishes population estimates each year, accounting for changes in the base population (defined by the last census) due to births, deaths, and migration (11). Many data sources...
are used to estimate changes, including births and deaths from the NCHS combined with data from the Internal Revenue Service, Centers for Medicare & Medicaid Services, Social Security Administration, and American Community Survey for migration (12). Average population sizes for each month across 2015 to 2019 were estimated. Cause of death was ascertained from the underlying cause stated on the death certificate and classified according to International Classification of Diseases, 10th Revision codes (COVID-19 [U071], cancer [C00 to C97], heart disease [I00 to I09, I11, I13, I20 to I51], stroke [I60 to I69], diabetes [E10 to E14], Alzheimer disease [G30], and unclassified deaths [R00 to R99]). These specific non-COVID-19 causes previously were shown to have resulted in excess deaths in 2020 (1). Because of data suppression rules, estimates for COVID-19 deaths were suppressed for persons younger than 15 years, Alzheimer disease deaths were suppressed for those younger than 55 years, and data for all other causes of death were suppressed for those younger than 25 years.

Age-specific excess deaths from March through August 2020 were estimated in 2 ways. First, the average annual number of deaths in each month in 2015 to 2019 was subtracted from the observed number of deaths in 2020 in each age group (that is, no adjustment was made for population growth and aging). Second, the expected number of deaths in 2020 was estimated with direct standardization by applying the age-specific death rate in 2015 to 2019 to population counts in 2020, by age and month, and then subtracted from the observed number of deaths in 2020 (that is, with adjustment for population growth and aging). Expected deaths are the number of deaths that would have occurred in 2020 if age-specific death rates were the same as in 2015 to 2019. Excess deaths were estimated by cause of death, age group (24 to 64 years and ≥65 years), and month.

Figure 1. Changes in age-specific U.S. population estimates and average annual deaths compared with the average number of deaths in the preceding 5 years, 2015 to 2020.

Top. U.S. population size, by age group and year, 2015 to 2020. Bottom. Annual deaths versus the average from the 5 previous years. Black bars indicate the number of deaths in a given year (that is, 2015, 2016, 2017, 2018, 2019, and 2020). Gray bars represent the average number of deaths for the 5 years before that year (that is, 2010–2014, 2011–2015, 2012–2016, 2013–2017, 2014–2018, and 2015–2019). Deaths in 2020 are limited to January through August and divided into COVID-19 deaths, unclassified deaths, and all other deaths. COVID-19 = coronavirus disease 2019.
Non-COVID-19 deaths were estimated by subtracting COVID-19 deaths from total excess death estimates. Because COVID-19 deaths occurred only in 2020, estimates of the number of COVID-19 deaths are not affected by temporal changes in population size or age structure. All estimates were rounded to the nearest 100 deaths.

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RESULTS
The U.S. Census Bureau estimates that the total U.S. population in 2020 is 5.22 million persons larger than the average size of the 2015 to 2019 population, including an increase of 5.04 million aged 65 years and older (10% increase), and that it decreased in some younger age groups (Figure 1, top). Annual deaths have also increased, such that from 2015 to 2019, deaths in each year exceeded the average number of deaths from the preceding 5 years by 114,000 to 163,000 deaths (Figure 1, bottom).

Between 1 March and 31 August 2020, 1,671,400 deaths were registered in the United States, according to provisional CDC data. Death rates per month in 2020 were higher than in 2015 to 2019 across all groups aged 15 years and older, with the largest absolute increases in the oldest age groups (75 to 84 years: +44.3 per 100,000 person-months; ≥85 years: +138.7 per 100,000 person-months). An average of 1,370,000 deaths were reported during March to August 2015 to 2019, for a crude excess of 301,400 deaths, including 173,300 due to COVID-19 and 128,100 (43%) due to non–COVID-19 causes (Figure 2). However, if the age-specific death rate in 2020 were the same as in 2015 to 2019, an additional 83,500 deaths would have occurred in March to August 2020 because of changes in population size and age composition alone, for a total of 1,453,500 expected deaths. After accounting for these population changes, we estimate that 217,900 excess deaths occurred during this 6-month period in 2020 (Figure 2, top). The number of COVID-19 deaths did not change, but the number of deaths from other causes declined to 44,600 (20% of the 217,900 excess deaths) (Figure 2, middle). Most of the difference between the 2 estimates of non-COVID-19 deaths (~82,100) occurred in the groups aged 65 years and older, in which population growth has been greatest and death rates are highest.

Figure 3, top, presents the number of excess deaths by month after adjustment for population growth. Thirty-five percent (n = 15,700) of non-COVID-19 excess deaths occurred in April (Figure 3, bottom). Fewer non-COVID-19 excess deaths occurred in May and June, before increasing again in July. There were 34,900 non-COVID-19 deaths among persons aged 25 to 64 years and 8,900 among those aged 65 years and older. Among persons

Figure 2. Data based on the CDC’s provisional release of death certificate data for 1 March to 31 August 2019 and 2020, and complete death certificate data for 2015 to 2018, by age group.

CDC = Centers for Disease Control and Prevention; COVID-19 = coronavirus disease 2019. Top. Total excess deaths, calculated by using 2 approaches: unadjusted (gray bars) and adjusted (black bars) for the growth and aging of the U.S. population. Middle. Provisional number of COVID-19 deaths among persons aged 15 years and older. Between 1 and 9 COVID-19 deaths occurred in persons younger than 14 years in at least 1 of the months; thus, exact counts were suppressed by the CDC. Bottom. Total non–COVID-19 excess deaths unadjusted (gray bars) and adjusted (black bars) for the growth and aging of the U.S. population. Deaths among persons younger than 15 years are all assumed to be non–COVID-19 deaths, because COVID-19 deaths were suppressed in these age groups.
**Figure 3.** Excess U.S. total and non-COVID-19 deaths, March to August 2020, by month, based on Centers for Disease Control and Prevention provisional release data.

Gray bars represent excess death estimates without adjustment for population changes, and black bars represent excess death estimates with adjustment for population changes. COVID-19 = coronavirus disease 2019.

COVID-19 as the underlying cause. Most of the 45,000 non-COVID-19 excess deaths occurred during April, July, and August, with far fewer in March, May, and June. Although this is a substantial number of excess deaths in a 6-month period, it is 83,000 fewer than would have been estimated if we had failed to account for population growth and aging.

Several previous studies estimating excess deaths in the United States did not account for the aging of the population and therefore overestimated non-COVID-19 deaths (1-5). Woolf and colleagues (3) recently reported 225,530 excess deaths from 1 March to 1 August, with only 67% attributed to COVID-19. Likewise, Bilinski and Emanuel (4) reported 236,000 excess deaths through 25 July 2020, with only 62% being COVID-19 deaths. Weinberger and colleagues (2) estimated 27,000 excess non-COVID-19 deaths by 30 May 2020, whereas we estimated 17,000 non-COVID-19 deaths by that date. Most recently, Rossen and colleagues (5) estimated 299,000 excess deaths through 3 October 2020, with 198,000 (66%) due to COVID-19.

By appropriately adjusting for the aging of the U.S. population, our analysis of excess non-COVID-19 deaths revealed several new findings. We found that most excess non-COVID-19 deaths occurred in persons younger than 65 years. In this group, heart disease and diabetes were the most common causes of excess deaths (on the basis of available causes released by the CDC). In persons aged 65 years and older, Alzheimer disease was the most common cause of these excess deaths, followed by diabetes and heart disease. Excess deaths from these other causes may reflect delays in care, reluctance to seek care, reduced hospital capacity, or undiagnosed COVID-19. A notable deficit in cancer deaths was observed during the period, across age groups. A possibility exists that COVID-19 is an important competing cause of death among the sickest patients with cancer. As of 14 November 2020, 11,000 COVID-19 deaths occurred in the United States for which cancer was also mentioned on the death certificate (13). Our approach assumes that cause-specific death rates have remained stable during 2015 to 2020, which may over- or underestimate expected deaths in the presence of temporal trends. The apparent deficit of cancer deaths is probably the result, in part, of declining cancer rates in recent years (14). A related issue is the possibility that changes occurred in cause-of-death attribution during the pandemic. Cause-specific death estimates might be over- or underestimated, depending on whether co-occurring COVID-19 diagnosis is coded as a contributing or the underlying cause of death. In addition, 27,300 deaths do not yet have a classified cause (that is, they were temporarily assigned an R code), which might explain some of the apparent deficits. Further, 28% of deaths occurring in 2020 did not fall into the cause-of-death categories currently released by the CDC; therefore, deaths from other causes may be occurring at excess rates. Of note, the CDC has not yet released data on accidental deaths, including drug overdoses, and suicides, which are of great concern given the potential impact of population growth and aging.

Aged 25 to 64 years, the most common specified causes of excess death were heart disease (n = 5600) and diabetes (n = 3000), although 9500 excess deaths were still unclassified as of the data release date. Among persons aged 65 years and older, the most common specific causes of excess death were Alzheimer disease (n = 6000) and diabetes (n = 4300), with 2100 excess deaths not yet assigned a cause. Monthly excess deaths by age and cause are presented in **Figure 4**. Unclassified deaths increased each month, consistent with delays in reporting specific causes of death. A notable deficit of cancer deaths was seen among persons aged 25 to 64 years (n = −5700) as well as those aged 65 years and older (n = −14,800).

**Discussion**

After the growth and aging of the U.S. population were taken into account, the 2020 COVID-19 pandemic resulted in an estimated 218,000 excess deaths between March and August, 80% (n = 173,000) of which had
Figure 4. Excess U.S. cause-specific deaths, March to August 2020, by month, among persons aged 25 to 64 years and those aged 65 years and older.

Bars represent the number of deaths in 2020 compared with 2015 to 2019, after adjustment for population changes. COVID-19 = coronavirus disease 2019.
mental health consequences of the pandemic and associated social distancing measures (15, 16).

Our analysis has several other limitations. First, our estimates of excess deaths are probably too low because of known delays in reporting death certificate data to the CDC, and more underreporting probably occurred in the most recent months. Provisional data released by the CDC on 12 November 2020 for deaths through 31 August 2020 were used to reduce the impact of reporting delays. Nevertheless, even this 10-week delay will miss deaths, because a recent CDC methodologic report indicated that 5.4% of deaths remain missing 13 weeks after they occur (17). Previous analyses of excess deaths included adjustment for estimated completeness of the provisional data (1, 2, 5). Given the large uncertainties in these adjustments, particularly in a pandemic, we prefer the more transparent approach of including a reporting delay and acknowledging the likely underestimation. Second, population estimates in intercensal years may have resulted in some degree of under- or overestimation of excess deaths, but this is probably small, especially for the older population, in which migration is relatively uncommon (12).

Excess mortality is a critical metric for quantifying the total impact of the COVID-19 pandemic on deaths in the United States and in other countries. Estimating the true burden of COVID-19 will require continued monitoring of excess deaths by cause. Additional non-COVID-19 deaths due to the pandemic will probably occur for many years because of delays in cancer screening, surgery, and other essential health care (18). Monitoring for these effects must include the impact of population changes, which may vary across population subgroups, including state and racial/ethnic groups. Data releases by the CDC and state health departments should include stratification by age groups so that these critical adjustments can be incorporated into monitoring efforts and future research.

The excess death estimates presented here may help guide clinical and public health interventions to prevent future unnecessary deaths by highlighting excess deaths by cause and age. The tremendous loss of life directly or indirectly due to COVID-19 over such a short period should not be understated. As of 30 November 2020, an estimated 265,000 COVID-19 deaths occurred in the United States, currently increasing by more than 10,000 deaths each week (19). In addition, as hospitalizations climb and intensive care units reach capacity, the number of non-COVID-19 excess deaths is likely to increase. Continued efforts to reduce COVID-19 infections and deaths remain an urgent priority.

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**ANNALS PERSONAE PRIZE**

Congratulations to Hung Q. Vo, MD, winner of the 2020 Annals Personae prize. Dr. Vo’s photograph was published on the cover of the 4 August 2020 issue (vol. 173, no. 3) and is reprinted below.

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