Methodology for the 2020 Demographic Analysis Estimates

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INTRODUCTION

Demographic Analysis (DA) is one of two methods that the U.S. Census Bureau will use to estimate coverage in the 2020 Census. The other method is the Post-Enumeration Survey (PES). Coverage error occurs when groups are undercounted or overcounted in the census. The DA program uses current and historical vital records, data on international migration, and Medicare records to produce national estimates of the population on April 1, 2020 by age, sex, the DA race categories, and Hispanic origin. The results will be compared to the census counts to evaluate net coverage error.

For the 2020 DA, we produced three sets of official estimates. In addition, experimental estimates are planned to be released at a later time. The official estimates use many data sources and methods that have been employed to evaluate previous censuses. The experimental estimates will explore new data and methods. In addition, we produced a range of estimates (low, middle, and high) for the three sets of official estimates to account for uncertainty in the data, methods, and assumptions used for the 2020 DA.

The 2020 DA estimates were developed using a basic population accounting approach. The main source of data for the births and deaths is the National Vital Statistics System maintained by the National Center for Health Statistics (NCHS). The foreign-born population for all birth cohorts was estimated primarily using a stock method and data from the American Community Survey (ACS). The estimates of the population born before 1945 (ages 75 and older) were developed using Medicare records.[1]

This document summarizes the methodology used to produce the official 2020 DA estimates. The first section provides a description of the three sets of official estimates and an overview of the general DA method. Next, we present more detailed information about the methods used to develop the birth, native death, international migration, military, and Medicare estimates. Finally, we discuss how we evaluated uncertainty in the DA estimates by producing a low, middle, and high series for each set of official estimates.

Different Sets of Estimates

The three official sets of DA estimates describe the nation's population for April 1, 2020 using different demographic detail. Table 1 describes the demographic characteristics and corresponding age cohorts for each set of estimates. The Black alone/non-Black alone estimates include information for all ages (0 to 85 and older) by sex. We restrict the race categories to Black alone and non-Black alone because of limitations in race reporting in the historical vital records. To reflect the increasing number of people who identify as more than one race in the census, we also produced estimates of the Black alone or in combination (AOIC)/non-Black

[1] The 2010 DA estimates used birth records starting in 1935. For 2020, Medicare records were used for the population born between 1935 and 1944 to mitigate issues with birth registration completeness for some of the cohorts born between 1935 and 1944. This change also leveraged improvements to the Medicare method.

AOIC population by sex for ages 0 to 85 and older. This is different from the 2010 DA estimates, where Black AOIC/non-Black AOIC estimates were only produced for the population aged 0 to 29. Finally, we produced Hispanic/non-Hispanic estimates by sex for the population aged 0 to 29, or birth cohorts from 1990 to 2020. Hispanic origin was not reported in vital records files by all states until 1990; therefore, these estimates can only be produced for the cohorts born after 1989.

All three official series will be used to calculate net coverage error. The Black alone/non-Black alone and Black AOIC/non-Black AOIC estimates will also be used as inputs into the PES estimates of coverage error. The PES operation uses the DA estimates to adjust for correlation bias between the PES and the census counts. Correlation bias occurs when the same populations that are missed in the census are also missed in the survey (Konicki 2012).

DA Method

The method used to produce the 2020 DA estimates can be conceptualized using a demographic accounting ledger (Table 2). The ledger shows the components, data sources, and methods for each cohort included in the 2020 DA estimates. The "*N*" in the table represents cells that will be populated with an estimate, while the "." represents cells that will not have an estimate. For example, we do not produce estimates for ages 0 to 74 with the Medicare records. Nor do we produce estimates of the Armed Forces overseas component for ages 0 to 17 or 65 and older. Thus, these are represented by a "." in the ledger. The table also shows how the components are either added or subtracted to estimate the resident population. The accounting ledger provides another way to conceptualize the complex process used to produce the 2020 DA estimates.

Before they can be included in the ledger, the components need to be standardized by age in 2020, a process that we refer to as "cohortization." For example, to cohortize the births in 1980, we would subtract 1980 from 2020, which equals 40 and is the age in 2020 of the cohort born in 1980. Births are the easiest component to conceptualize the cohortization process, while other components are more complicated. To cohortize deaths, we need to determine which birth cohort the person was in and then calculate what their age would have been in 2020. For example, if a person died in 2005 at age 25, then we subtract 25 from 2005 to get 1980, and from there we can determine that they would have been age 40 in 2020.

The examples above are simplified to illustrate how the components are cohortized. The actual process of cohortization is more complex because births are spread out over each year, and the age of the person on April 1, 2020 will vary depending on when they were born. People born in 1980 could either be 39 or 40 years old on April 1, 2020 and we account for that in our process. For births, we have the date of birth; therefore, we can cohortize their age exactly. For other components, we divide the population in half and subtract 1 from the age in 2020, a process referred to by demographers as age centering.

The sections below detail the data and methods used to estimate each of the nine components in the 2020 DA Ledger. After the components have been cohortized and entered into the ledger, the resident population on April 1, 2020 is calculated by adding and subtracting the different components accordingly. Tables 3, 4, and 5 provide the results for each set of estimates.

BIRTHS

Births are the foundation of the DA estimates. For the 2020 DA, we used NCHS birth records from 1945 to 2018 and national birth totals from 2019 through the first quarter of 2020.[2] In this section, we present the methodology used to assign race to births, develop consistent race assignment over time, correct for under-registration in the historical births records, and develop the range of estimates for births.

Assigning Race to Births

Birth records do not include race and ethnicity detail for the child, but there is information about the race and ethnicity of the mother and father. There are several approaches that the Census Bureau has used to assign race and Hispanic origin to births using the characteristics of biological parents. The approaches include (1) the "Minority Rule" where the race of a non-White parent in mixed-race couples is assigned to the birth; (2) the "Mother Rule" where the child is assigned the race of the mother; (3) the "Father Rule" where the child is assigned the race of the father; (4) the "Both Parent Rule" where a particular race is assigned to the child only when both parents are in that race group; and (5) assigning race based on proportions from census data in a process that we call "Kidlink," which is described in more detail below.[3]

Except for the Kidlink process, the different race assignment rules can be thought to reflect a continuum relative to designating births as Black: the Both Parent Rule is the most restrictive approach because both parents must be Black, while the Minority Rule is the least restrictive because only one parent needs to be Black. Research has shown that, historically, the Father Rule was the most consistent of the three rules with census race classification (Passel 1992; Robinson 1991). However, births to parents of differing races has steadily been on the rise, which has made race assignment more complex and prompted the need for the Kidlink method.

Kidlink Method

The Kidlink method is the process that the Census Bureau currently uses to assign race and Hispanic origin to birth records (Guarneri and Dick 2012). The Kidlink method uses a combination of parents' and children's race and Hispanic origin responses from a census or

[2] There is generally a two-year lag for the birth records from NCHS. To produce estimates of current births, we used preliminary national totals from NCHS to set levels. The characteristics were developed by using sex, race, and Hispanic origin distributions from the most recent microdata that were available, which was the 2018 file.
[3] When used by NCHS, the Minority Rule included additional procedures for cases where there was more than one non-White parent. We have described it more broadly here as it applied to the race classification used for DA.

survey to assign race and Hispanic origin to aggregated birth records. Unlike the other approaches used to assign race to birth records, this method accounts for how people would identify the race of their child on the census instrument.

The first step in the Kidlink method is to link data from the child to the potential biological parents living in the same household. We use the relationship status information in the census to identify the potential biological parents, which includes a category for biological child of householder.[4] We then make the assumption that the spouse or unmarried partner of the householder is also the biological parent of the child.[5] We also use data for single-parent households to assign race where the father's information is missing from the birth certificate. For the 2020 DA, we are only using information on 0-year-olds. Research has shown that the assumption that the spouse or unmarried partner of the householder is also the biological parent of the child is not always accurate for older children (Jensen and Eickmeyer 2019).

Next, we calculate proportions for the child's race given the specific race combination for the parents. For example, we calculate the proportion of children whose race is reported as Black when the mother's race is Black and the father's race is non-Black. The proportions are then applied to aggregated birth records to develop the race detail for the birth estimates.

For the 2020 DA, we developed period-specific Kidlink files using the 1980, 1990, 2000, and 2010 Census files. For the 2010 DA, we used Census 2000 data exclusively to calculate the Kidlink proportions that we then applied to birth records from 1980 to 2010. Using period-specific files accounts for variation in how people identify the race of their child over time. To further capture change over time, we used linear interpolation to estimate Kidlink proportions in the years between censuses.

Implementing period-specific Kidlink files required that we harmonize the race of parents between births and census data for each decade. This process was complicated by how race reporting standards for the federal government have changed over time. The Office of Management and Budget (OMB) sets guidelines on how federal statistical agencies collect and disseminate data on race and ethnicity.[6] The current OMB standards were set in 1997 and allow for multiple race reporting. As a result of this change to race standards in 1997, the 2000 Census gave respondents the opportunity to identify as more than one race for the first time. The standard certificate of live birth issued by NCHS was updated to reflect the new multiple race

[4] Relationship status in the census measures the relationship of all household members to the householder only. Therefore, we cannot be certain that the spouse or unmarried partner of the householder is actually the biological parent of the child. In addition, we cannot use information on children that are not the biological child of the householder, such as a stepchild or grandchild of the householder.

[5] Information on the unmarried partner of the householder was used for the 2000 and 2010 Kidlink files. This information was not available on the 1980 Census and was not coded in a way conducive to its use on the 1990 Census file.

[6] The 1997 OMB standards include five race categories (White, Black, American Indian and Alaska Native, Asian, and Native Hawaiian and Other Pacific Islander) and two ethnic groups (Hispanic and non-Hispanic). The 1997 guidelines were an update to the 1977 OMB standards, which only included four race categories. For more information, see: https://www.govinfo.gov/content/pkg/FR-1997-10-30/pdf/97-28653.pdf

categories in 2003. States gradually changed their birth certificates to incorporate the new OMB guidelines throughout the decade, with 100 percent compliance in 2016.

To mitigate the discrepancy in race classification between births and census data, we use race bridging factors developed by NCHS that convert multiple race responses to a likely "primary" single race. Additionally, we use a set of factors developed by the Census Bureau to parse out multiple-race responses from the single race classification system that was in use before the 1997 OMB standards (Sink and Colby 2014). Thus, we have a process that converts the "new" race that allows for multiple race reporting back to the "old" race that includes only single race categories, and vice versa. Depending on the decade, we use one of the two sets of factors to ensure consistency in parent race between births and census data. For example, we apply the bridging factors to the race of parents in 2000 Census data to obtain the 2000 Kidlink file, converting the multiple race data reported on the Census back to single race in order to align with the race categories on the birth records.

The DA Kidlink files have the following race categories for children: (1) Black alone, (2) Black in combination with any other race (excludes Black alone), and (3) all other races. These race categories are mutually exclusive, and we derive both births series by race (Black alone/non-Black alone, and Black AOIC/non-Black AOIC) with the appropriate aggregation. For example, estimates of Black AOIC births are the sum of Black alone and Black in combination births.

The Kidlink file was an substantial innovation in the 2010 DA that made it possible to produce estimates of the Black AOIC population under 30 years old. This was the first time DA estimates were produced for a multiple-race population. For 2020, our method reflects the outcome of innovative research that has been done on Kidlink this past decade to improve how race and Hispanic origin is assigned to birth records.

Race Consistency in Births over Time

The data used to build DA estimates generally reflect the population by age and sex with high accuracy. On the other hand, there is substantial uncertainty surrounding the estimates by race that can potentially confound our analysis of coverage by race. For the 2020 DA, we used a method that mitigates the effect of using different race assignment methods in historical births compared to more recent births. As noted above, births after 1979 in the DA process receive race from the Kidlink method, as opposed to the Father Rule. King et al. (2019) makes use of the relationship between Kidlink-assigned births and births assigned using the Father Rule to adjust the 2010 DA birth estimates, which resulted in more consistent DA estimates by race and age. The adjustments made to the 2010 DA estimates led to improved estimates of net coverage error and coverage differentials by race in 2010.[7]

[7] Net coverage error here is defined as 100*(Census counts - DA estimates) / (DA estimates).

For 2020 DA, we used the method developed by King et al. (2019) to adjust historical Black births derived from the race of the father to make them more consistent with Kidlink births. This allowed us to produce estimates for the Black AOIC population for all ages, and not just the births since 1980 as was done for the 2010 DA. The method parses out separate estimates of Black alone and Black AOIC births from historical births before 1980, for which there is no Kidlink file available. Two sets of adjustment ratios were developed that were then used to derive birth-year-specific "conversion factors." The conversion factors were applied to historical births (1945-1979) based on the Father Rule to bring them into better alignment with Kidlink births from 1980 to 2020.

Birth Registration Completeness

A national system for registering births did not exist until 1933. A series of Birth Registration Completeness Tests (BRT) conducted in 1940, 1950, and 1964 to 1968 found that the number of births registered with NCHS in those early years underestimated the true number of live births (Shapiro 1950; U.S. Census Bureau 1973).[8] Consequently, NCHS and other analysts using historical birth records typically make adjustments for birth registration completeness.

However, some researchers have hypothesized that the adjustment factors developed using the BRTs are too high. Robinson (1991) argues that matching error most likely understated birth registration completeness in 1940. Passel (1992) asserts that the matching error bias in the 1940 BRT was due to incomplete follow-up in at least one third of all states, mostly in the South with large Black populations. Implausible cohort patterns in net undercount of the Black cohort born 1935 to 1945 further support existence of bias in the 1940 BRT.

In 1990, the Census Bureau started making adjustments for the possible over-correction of historical births. These adjustments to birth registration completeness were used to produce the 2000 and 2010 DA estimates. For the 2020 DA, we used the same adjustments to the under-registration factors for historical birth records. These include regression-based correction factors for Black births over 1945 to 1985 to correct for the bias in under-registration in the 1940 BRT.

Range for Birth Estimates

We produced a range of birth estimates to account for uncertainty in the birth records and the methods used to assign race and Hispanic origin information to the birth records. First, we adjusted the corrections for birth registration completeness by altering the number of births added to the official registered total in the middle series. Specifically, we reduced the total additional births by 30 percent for the low series and increased the total additional births by 30

[8] NCHS did not form as an agency until 1960. Up until 1946, the Census Bureau processed the birth data and then delivered it to the National Office of Vital Statistics. For more information, see: https://www2.census.gov/library/publications/1949/compendia/hist_stats_1789-1945/hist_stats_1789-1945-chC.pdf

percent for the high series. The 30 percent adjustment was the same adjustment used for births in the 2010 DA estimates and was based on a sensitivity analysis conducted at that time (Devine et al. 2012). The birth registration adjustment only impacts births from 1945 to 1985, at which point all states had started reporting vital statistics in electronic format (National Research Council Committee on National Statistics 2009). For years after 1985, we assume birth totals are 100 percent complete.

In the years following 1985, our uncertainty in the DA estimates of births centers around race and how we assign it. As we move further from 1985, the discrepancy between the race reporting systems used by NCHS and Census increases. Furthermore, assigning race to births becomes more complex as the number of births to parents of differing races increases, accompanied by changing attitudes about race in general.

The race assignment methods discussed earlier (the Minority Rule, Mother Rule, etc.) give us information about the composition of the parents' race in the birth data in each year and provide logical benchmarks to evaluate the births by race from the Kidlink method. The differences between the Kidlink series and the other simple race assignment rules express our uncertainty about assigning race with Kidlink. We can derive low and high series of Black alone and Black AOIC births by pooling together the information from the different race assignment rules and using the differences among them to express our uncertainty about race.

For estimates of Black alone births for each birth year, we calculated the average estimate using alternate race assignment rules and the Kidlink method. The alternate race assignment rules for the Black alone series are the Mother Rule and the Both Parent Rule. These alternate race assignment rules historically track with the Black alone births identified with the Kidlink method. Next, we derived the mean absolute deviation (MAD) from the average series, which summarizes the variation among the series using competing race assignment rules. The MAD is a robust measure of variation that does not exaggerate the influence of extreme values, as compared to the standard deviation, for example.

The Black alone births from the Kidlink method comprise the middle series. We adjusted the middle series of Kidlink births up and down by one MAD to obtain the high and low Black alone series of births, respectively. This means that the high series of non-Black alone births is the difference between total births and the low series of Black alone births. Similarly, the low series of Non-Black alone births is the difference between total births and the high series of Black alone births.

The high and low Black AOIC series are obtained in a similar manner, albeit with a different set of alternate race assignment rules. The alternate race assignment rules for the Black AOIC births are the Father Rule and the Minority Rule.

Finally, we used the Minority Rule for the high series of Hispanic births and the Mother rule for the low series of Hispanic births. We did not use the MAD method here, since Hispanic origin assignment is a much more straightforward process than race, one that is not confounded by differing

classification systems between NCHS and Census. For this set of estimates, the high series of non-Hispanic births is the difference between the total births and low series of Hispanic births, while the low series of non-Hispanic births are total births less the high series of Hispanic births.

INTERNATIONAL MIGRATION

International migration is the movement of people across a national border in which a change in residence has occurred. It is measured as either the migrant stock population at one point in time or the annual flows into and out of a country. For the 2020 DA estimates, we produced four components related to international migration. The largest component is the foreign-born population aged 0 to 74 living in the United States on April 1, 2020. We also developed estimates of the native population born from 1945 to 2020 who had moved abroad and were not living in the United States on April 1, 2020. In addition, we produced estimates of the population that migrated from Puerto Rico and were living in the United States at the time of the 2020 Census. Finally, we estimated the population born abroad of U.S. citizen parents that are now living in the United States.

Foreign-Born Population

The foreign-born population consists of anyone living in the United States on April 1, 2020 who is not a U.S. citizen by birth, including naturalized citizens. The foreign born make up the largest subset of the resident population not in the DA birth records. The stock method that we introduced in the 2020 DA replaced previous DA estimates of immigration and emigration flows and migrant stocks. The previous method lacked input data for measuring repeated migration events over several decades, especially historical circular migration and emigration flows, which added considerable uncertainty to previous DA population estimates. The stock estimate is based on recent ACS data and reflects the cumulative outcome of immigration, emigration, and deaths to the foreign born.

We used the Hamilton-Perry method to project characteristics of the foreign born to April 1, 2020. This method constructed cohort change ratios (CCRs) from the ACS by age, sex, race, and Hispanic origin for 2017 to 2018 and 2018 to 2019. We assumed that the decelerated growth of the foreign born since 2017 continued in 2020.[9] We projected the foreign-born characteristics to 2020 by applying the averaged CCRs to the 2019 ACS. We then prorated the projection to April 1, 2020. We smoothed the age distributions to minimize age heaping in the ACS inputs, which produced the projected characteristics for the foreign-born stock estimates.[10]

[9] We did not adjust to account for the global COVID-19 pandemic. We assumed the severe effects of the pandemic on foreign-born migration to and from the U.S. did not to begin until the last few weeks leading up to the April 1 reference date.

[10] DA and the U.S. Census Bureau Population Projections programs use penalized least squares to preserve the underlying age structure (“smoothing”), which produces better results than moving averages.

For the low series, we controlled the Hamilton-Perry projection to match the foreign-born race totals based on an April 1, 2020 linear projection of the 2017 to 2019 ACS. The low series assumes complete coverage of the foreign born. For the middle series, we took the Hamilton-Perry projection and applied ACS coverage factors by age group and sex. We averaged four series of the 2000-based foreign-born coverage factors by Hispanic origin from Jensen et al. (2015) and combined them with the 2005 to 2010 Mexican-born coverage factors derived from the death registration and net migration series from Van Hook et al. (2014). For the high series, we inflated the middle series by 2.5 percent. This centered the middle series between the low and high series.

Net Native Migration

Net native migration accounts for persons in the DA birth records who had emigrated as of April 1, 2020. We replaced the 2000 net civilian citizen component used by previous DA programs with a base estimate of the U.S. born living abroad as of April 1, 2000.[11] We used foreign data from about 80 countries from Schachter (2008) to create the base estimate. The base estimate reflects all U.S.-born civilians reported in the foreign data regardless of citizenship status. Age and sex distributions come directly from data from other countries. Race and Hispanic origin distributions come from the ACS 5-year estimates of the civilian native population who returned from abroad by place of last residence.

Next, we used the Foreign Census Method to estimate net native migration that occurred since April 1, 2000. This is a residual method that used foreign censuses, surveys, and registers to estimate change in the U.S.-born population living overseas (Fernandez 1995, Gibbs et al. 2003, Schachter 2008). [12] We applied NCHS survival rates to the U.S.-born population measured in the foreign data at Time 1 and survived the population forward to get the expected population at Time 2, assuming no migration had occurred. Next, we tabulated the observed population measured in the foreign data at Time 2. The residual or difference between the expected and observed population represents net migration between the United States and the foreign country from Time 1 to Time 2. We repeated the residual estimation for approximately 100 countries. Mexico, Canada, and the Philippines represented over 50 percent of net native migration. The top 10 countries represented over 75 percent of net native migration. We adjusted the reference periods from the foreign data to align with the U.S. intercensal period when possible. For countries with lagged data, we held migration levels constant.

[11] The 2000 DA net civilian citizen migration component used data from 1950 to 1970 U.S. censuses and post-1970 data on federal civilian employees and military dependents living overseas from the Office of Personnel Management, State Department, and Department of Defense (Robinson 2011). The 2010 DA used foreign data to add 10 years of native migration to the 2000 estimate.

[12] Some counties do not report place of birth in their census, survey, or population register, but do include country of citizenship. In this case, we used U.S. citizenship as a proxy for the population born in the United States.

We estimated age and sex directly from the Mexican and Canadian residuals.[13] For all other countries in which the domain sizes were too small, we collapsed country residuals into a total residual. Then we distributed the total by age and sex based on smoothed, aggregated characteristics from a selection of large destination countries across world regions. We used ACS 5-year characteristics of the civilian native population by last country of residence to distribute race and Hispanic origin.

Research has shown that there were approximately 200,000 young children aged 0 to 4 that were born in the United States but living in Mexico at the time of the 2010 Census (Jensen et al. 2018). These children were not accounted for in the 2010 DA estimates. Therefore, this was one subgroup of the native migrant population that we wanted to ensure was included in the 2020 estimates. To better measure this population, we used the 2018 ENADID survey from Mexico instead of Mexico's 2010 census in order to have more current estimates of this population. In addition, we used characteristics directly from the 2018 ENADID survey to get a more accurate age profile for native migrants to Mexico.

Finally, to create the range, we collapsed net migration by age, sex, race, and Hispanic origin to produce the middle series. We assumed a high level of non-measurable uncertainty in the net native migration due to aggregate errors in the foreign data, omitted countries, and different reference periods. To account for some of this uncertainty, we applied a 10 percent adjustment factor to produce a low and high series. The level of adjustment was determined using a sensitivity analysis.

Net Puerto Rico Migration

Net Puerto Rico migration represents net migration between the United States and Puerto Rico since 1945.[14] This component accounts for the population that migrated to the United States from Puerto Rico that is not in the DA birth records. We used the 2000 DA estimate of cumulative net migration from 1945 to 2000. Then we added annual net migration from 2000 to 2020. Annual in-migration since 2000 is based on the ACS estimate of the population whose residence one year ago was in Puerto Rico. Annual out-migration since 2005 is based on the Puerto Rico Community Survey (PRCS) estimate of the population whose residence one year ago was in the United States. Since the PRCS did not start until 2005, we subtracted in-migration from the Puerto Rico net migration component in the Census Bureau's Vintage 2010 estimates series to estimate out-migration for the 2000 to 2004 period.

In 2017, Puerto Rico was struck by a severe hurricane that impacted migration patterns between the island and the U.S. mainland and also disrupted the PRCS data collection (Schachter and Bruce 2019). Since the PRCS suspended data collection for part of 2017, we incorporated airline passenger data from the Bureau of Transportation Statistics to account for the large inflow of Puerto Ricans to the United States in 2017 due to Hurricane Maria and the large return flow in 2018.

[13] The latest input data for the residuals are the 2018 Mexican Survey of Demographic Dynamics (ENADID) and Canada's 2016 census. We projected the residuals to April 1, 2020.
[14] For statistical purposes, the Census Bureau defines the United States as the 50 states and District of Columbia.

We used 5-year ACS/PRCS characteristics of people whose residence one year ago was in Puerto Rico and the United States to distribute inflows and outflows respectively. Net migration is the difference between in-migration and out-migration.[15] We did not produce a low or high series since we have relatively high confidence in the surveys for measuring this type of migration.

Born Abroad of U.S. Citizen Parents

We used a stock method to estimate the population born abroad of U.S. citizen parents that had migrated to the United States as of April 1, 2020. This component accounts for U.S. citizens by birth who are not in the DA birth records. The stock method replaced 2000 and 2010 DA methods which included this population in the 2000 net civilian citizen component and residual estimate.

We used the Hamilton-Perry method to project the 2019 ACS characteristics of the population born abroad of U.S. citizen parents to April 1, 2020. This method constructed CCRs by age, sex, race, and Hispanic origin from the ACS estimates of the born abroad of U.S. citizen parents stock for 2017 to 2018 and 2018 to 2019. Then we applied CCRs to the 2019 ACS to project the stock to 2020. Next, we prorated the projection to April 1, 2020. We smoothed the age distributions to minimize age heaping in the ACS inputs. We did not produce a low or high series due to our relatively high confidence in the survey for measuring this stock.

NATIVE DEATHS

In past decades, the DA deaths component has accounted for mortality in the entire resident population. However, the new method that we developed to estimate the foreign-born population this decade eliminated the need to account for foreign-born deaths. Therefore, the deaths component of the 2020 DA measures mortality to the resident population born in the United States from 1945 to 2020. The native-born deaths also exclude deaths to the population born abroad of U.S. citizen parents.

The data used to estimate the native deaths comes from NCHS vital death records. For the deaths from 1980 to 2018, we produced estimates of native deaths using microdata on deaths from NCHS that include information about the place of birth of the decedent. For the 2019 deaths, we used national totals reported by NCHS and assigned characteristics to these totals using the 2018 microdata. For January 1 to March 31, 2020, we used preliminary monthly totals released by NCHS and, again, used the 2018 microdata to assign characteristics.[16]

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[15] DA followed a similar methodology to the Population Estimates Program's Puerto Rico population estimates. For more information, see https://www.census.gov/data/datasets/time-series/demo/popest/2010s-detail-puerto-rico.html.
[16] The monthly totals for 2020 did include the initial impact of the COVID-19 pandemic; however, the pandemic was still in its earliest phase before April 1, 2020.

From 1964 to 1980, the NCHS death records did not include information about place of birth, which is needed to produce death estimates by nativity. To estimate native deaths during this period, we averaged the proportion of the deaths in 1980, 1990, and 2000 by age and sex that were foreign-born and used these averages to estimate the number of foreign-born deaths in the historical DA deaths files from 1945 to 1980.

During these years, the total number of deaths that we need to estimate is low because of the relatively young age structures of the populations that we are concerned with (birth cohorts from 1945 to 1979), which had low rates of mortality. For example, in 1950, we are only interested in deaths to the population aged 0 to 5; 0 to 15 in 1960; and 0 to 34 in 1979. Stated differently, even though the native deaths estimate from 1945 to 1980 covers a fairly large period, the total number of deaths is relatively small because we are only focused on deaths to people born between 1945 and 1980. As the population of interest was relatively young across these decades, there are fewer deaths to account for. In addition, before 1965, immigration was not as common; therefore, the proportion of the population that was foreign born was relatively small (Vespa et al. 2018).

Ideally, we would have used mortality data with information about nativity for the deaths from 1945 to 1980, but that information was not available. We did test using proportions of the population from the earlier periods that were foreign-born, but this did not have a strong correlation to the proportion of deaths that were foreign-born by age and sex. We chose to use mortality data instead of population data. Further, a range of estimates was not produced for the native deaths component.

ARMED FORCES OVERSEAS

The 2020 DA estimates include components for the Armed Forces overseas (AFO) population and deaths to the Armed Forces population that occurred overseas. We derive the estimate of the total AFO population from data collected by the Defense Manpower Data Center (DMDC). DMDC provides the Census Bureau with monthly tabulations of military personnel stationed outside the United States by age, sex, race, and Hispanic origin. The AFO component uses new data for active military members as of the end of March 2020 and is projected to include April 1, 2020. Data for reserve members were held constant from March 2018, the last time we received comparable data. However, the number of reserve members serving abroad is relatively small.

The AFO deaths is a separate component because the death records that we receive from NCHS do not include non-resident deaths. Under this definition, deaths that occur to Armed Forces personnel while overseas are considered non-resident. The estimate of AFO deaths accounts for deaths to the cohorts born between 1945 and 2020, a period which includes the Vietnam War, Operation Desert Storm, the wars in Iraq and Afghanistan, and other operations.

We used data from several different sources to develop the estimates of AFO deaths. First, we used historic data from the Defense Casualty Analysis System (DCAS) which we accessed through the National Archives to measure AFO deaths from 1950 to 2000. Next, we used DMDC

data that were previously included in the 2010 DA estimates of deaths from 2000 to 2010. Finally, we used current DCAS data to estimate AFO deaths from 2010 to 2020.[17] Race and Hispanic origin were imputed for the current DCAS data because this information was not included on the files. Also, we prioritized the 2010 DA estimates over the DCAS data, which were actually available from 2006 to 2020, because the DA estimate contained race and Hispanic origin information. For each of these data sets, we recoded the race data to match the DA categories and cohortized the estimates to April 1, 2020 using age information in the data. Estimates of AFO deaths are not available for the Black alone or in combination population; therefore, we make the assumption that the Black AOIC deaths are the same as the Black alone deaths. In addition, a range of estimates was not constructed for the AFO components.

OLDEST AGES

The 2020 DA program used adjusted Medicare data to estimate the population aged 75 and older on April 1, 2020. These cohorts were born before 1945 when vital records were either not complete or not available. Administrative records provide valuable information that can be used for demographic analysis and research; however, many records systems were not originally designed for this purpose, which can create challenges. In this case, the Medicare enrollment data required substantial cleaning for use in demographic estimates, including the removal of duplicates, deceased records, and enrollees with terminated Medicare benefits.[18] We also needed to remove records with implausible age information. There are a non-trivial number of enrollees at the oldest ages with no reported date of death. Simultaneously, the system does not contain records for people who are not eligible to enroll.

The 2020 DA method applied adjustments to current enrollees to account for both those who do not belong in the universe and those who were never in the administrative records, as follows:

1) Identify universe of enrolled population from the most current Medicare file and the recorded deaths over the year (as of April 1, 2020);
2) Adjust for implausible survival in the oldest ages;
3) Adjust for under-enrollment; and
4) Sum the adjusted Medicare estimates to derive the population aged 75 years and older by single year of age, sex, and race.

The first step in producing the DA estimates for the population aged 75 and older was to select the universe of records from the most current Medicare file, which in this case was a 2020 file. Data preparation began with removing duplicate records that exist for the same enrollee. Each remaining record in the file was assigned a Protected Identification Key (PIK), which uniquely identifies individuals and enables linking across administrative, decennial census, and survey data sources while preserving privacy (Wagner and Layne 2014).

[17] The estimates of AFO deaths from 2010 to 2020 were produced using data downloaded from the DCAS website: https://dcas.dmdc.osd.mil/dcas/pages/casualties_ofs.xhtml.
[18] We identify and remove enrollees with terminated benefits to ensure that the adjustment factors derived from survey data refer to the same population.

Since most Medicare enrollment records have Social Security Numbers, PIK assignment in Medicare data is generally of high quality. There is a small subset of records in the Medicare file with identical PIKs. A comparison of the demographic characteristics and benefits status between duplicate record pairs and the strength of the PIK assignment method indicate that records with the same PIK generally belong to the same enrollee. We selected one record for each duplicate pair of PIKs—a process we refer to as un-duplication—to obtain the Medicare enrolled population.

The second step in the overall process was to adjust for implausible survivorship of enrollees in the oldest ages. In other words, we account for low data quality at these ages. Even after removing records with terminated health benefits, there are still implausibly high counts of enrollees by age after about age 90 in most demographic groups. This is supported by research that has compared the counts of deaths from NCHS to counts from the Medicare file and found the Medicare deaths to be stable across age and time (Sabo et al. 2019). To make the adjustment, we calculated the ratio between the total enrolled, living Medicare population to the count of deaths in the Medicare file by age. The counts of enrolled population by age are of higher quality in the younger ages, and there is a clear observed relationship between the enrolled population and the counts of deaths by age. Inflated ratios in the oldest ages reveal data quality issues, and these were used to isolate and remove records without a reported death that were most likely deceased.

The third step in the process is to account for under-enrollment in the Medicare program. Under-enrollment occurs when people delay enrollment after they are eligible, never enroll, or are not eligible to enroll in Medicare. We used under-enrollment factors derived from the 5-year ACS responses on health care coverage. The ACS under-enrollment factors are calculated by sex, single-year age, and the DA race categories of Black/non-Black. There is considerable sampling variation in the oldest ages, so we used a penalized least squares approach to smooth the adjustment factors for these ages. Preliminary attempts at smoothing produced factors that are more demographically reasonable.

To develop the range for the oldest age population, we varied the under-enrollment factors. For the low series, we did not adjust for under-enrollment in the Medicare records. We used the under-enrollment factors as calculated for the middle series, and inflated the factors up by 5 percent for the high series.

UNCERTAINTY

Uncertainty in the DA estimates can come from many different sources. We produced the DA estimates using historical vital records, estimates of international migration, and other data sources, each with some potential measurement error. For instance, there is non-sampling error in the birth records prior to 1980 because of registration completeness. Meanwhile, the estimates of the foreign-born population are derived from the ACS and have sampling error. In addition,

the process that we used to produce the estimates may cause estimation error. Finally, there may be classification error between the estimates and the census counts caused by differences in race reporting or age distributions (e.g., age heaping). Therefore, it is important to estimate uncertainty or error in the final DA estimates.

For the 2020 DA, we produced a range of estimates—low, middle, and high—to reflect the many sources of uncertainty described above. The range was developed by grouping the different series of components together based on the level of the estimate. For example, we paired the low series of births with the low series of international migration to produce the low series of DA population estimates. As noted throughout the methods statement, we did not produce a high and low series for all components of population change. For components with only one series of estimates, the same assumption was included in the high, middle, and low series of DA estimates. Tables 6, 7, and 8 provide an overview of the assumptions used to develop the range of estimates for each series.

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TABLES

Table 1. Description of the Three Official Sets of 2020 DA Estimates

Populations	Characteristics	Cohorts
Black alone/non-Black alone	Age, sex, race	0-85+
Black alone or in combination/ non-Black alone or in combination	Age, sex, race	0-85+
Hispanic/non-Hispanic	Age, sex, Hispanic origin	0-29

Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).

Table 2. 2020 Demographic Analysis Ledger by Component, Data Source, and Cohort

	Natural Increase		International Migration				Armed Forces		Oldest Ages	
	Births	**Native Deaths**	**Foreign-Born Population**	**Born Abroad of U.S. Citizen Parents**	**Native-Born Net Migration**	**Net Migration from Puerto Rico**	**Armed Forces Overseas**	**Armed Forces Overseas Deaths**	**Population Ages 75 and Over**	**Resident Population**
	Vital records with correction to birth registration adjustment	Vital records	Projected ACS data with adjustments for coverage	Projected ACS data	Foreign Census Method; adjustment for children in Mexico	ACS, PRCS, and U.S Air Carriers Traffic and Capacity data	Administrative records from the Defense Manpower Data Center	2010 DA Estimates and archival data	Medicare records; ACS enrollment factors	Total
Age in 2020	**1945-2020 (+)**	**1945-2020 (-)**	**Stock in 2020 (+)**	**Stock in 2020 (+)**	**1945-2020 (+)**	**1945-2020 (+)**	**Stock in 2020 (-)**	**2020 (-)**	**2020 (+)**	**April 1, 2020**
0-17	*N*	*N*	*N*	*N*	*N*	*N*	.	.	.	*N*
18-64	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	.	*N*
65-74	*N*	*N*	*N*	*N*	*N*	*N*	.	*N*	.	*N*
75-99	.	.	.	.	.	.	.	.	*N*	*N*
100+	.	.	.	.	.	.	.	.	*N*	*N*

Note: The "*N*" in the table represents cells that will be populated with an estimate, while "." represents cells that will not have an estimate. Acronyms in this table include American Community Survey (ACS), Puerto Rico Community Survey (PRCS), and Demographic Analysis (DA).

Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).

Table 3. Population Estimates and the Components Used to Construct the U.S. Resident Population by Sex and Race (Black Alone/Non-Black Alone): April 1, 2020 (In thousands)

Series and Component	Total Population	Black Alone			Non-Black Alone		
		Both Sexes	Male	Female	Both Sexes	Male	Female
Low Series							
Total population	330,730	44,606	21,756	22,850	286,123	142,053	144,071
Births	288,438	42,584	21,583	21,001	245,854	126,159	119,695
Deaths	22,412	4,645	2,818	1,826	17,768	11,156	6,612
International migration	43,214	4,865	2,327	2,538	38,349	18,713	19,636
Medicare-based estimates	21,491	1,802	665	1,137	19,688	8,337	11,351
Middle Series							
Total population	332,601	45,527	22,219	23,308	287,075	142,554	144,520
Births	288,908	43,361	21,978	21,383	245,547	126,004	119,544
Deaths	22,412	4,645	2,818	1,826	17,768	11,156	6,612
International migration	44,256	4,962	2,376	2,586	39,294	19,235	20,060
Medicare-based estimates	21,849	1,848	683	1,165	20,001	8,472	11,529
High Series							
Total population	335,514	46,535	22,716	23,819	288,978	143,421	145,557
Births	289,379	44,137	22,373	21,764	245,242	125,849	119,392
Deaths	22,412	4,645	2,818	1,826	17,768	11,156	6,612
International migration	45,591	5,099	2,442	2,657	40,492	19,827	20,665
Medicare-based estimates	22,956	1,943	719	1,225	21,013	8,901	12,111

Notes: Estimates may not sum to totals shown because of rounding. The deaths component includes deaths to Armed Forces overseas and deaths to the native resident population. Net international migration includes the international migration of both native and foreign-born populations. Specifically, it includes: (a) the foreign born, (b) the net international migration of the native born, (c) the net migration between the United States and Puerto Rico, and (d) the population born abroad of U.S. citizen parents living in the United States on April 1, 2020.

Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).

Table 4. Population Estimates and the Components Used to Construct the U.S. Resident Population by Sex and Race (Black AOIC/Non-Black AOIC): April 1, 2020 (In thousands)

Series and Component	Total Population	Black AOIC			Non-Black AOIC		
		Both Sexes	Male	Female	Both Sexes	Male	Female
Low Series							
Total population	330,730	49,147	24,041	25,105	281,583	139,767	141,816
Births	288,438	46,903	23,780	23,123	241,534	123,961	117,573
Deaths	22,412	4,803	2,912	1,891	17,609	11,062	6,547
International migration	43,214	5,244	2,508	2,736	37,970	18,531	19,438
Medicare-based estimates	21,491	1,802	665	1,137	19,688	8,337	11,351
Middle Series							
Total population	332,601	50,317	24,632	25,685	282,284	140,141	142,143
Births	288,908	47,869	24,273	23,596	241,039	123,709	117,330
Deaths	22,412	4,803	2,912	1,891	17,609	11,062	6,547
International migration	44,256	5,403	2,588	2,815	38,853	19,022	19,831
Medicare-based estimates	21,849	1,848	683	1,165	20,001	8,472	11,529
High Series							
Total population	335,514	51,529	25,234	26,295	283,984	140,903	143,081
Births	289,379	48,836	24,766	24,070	240,543	123,457	117,087
Deaths	22,412	4,803	2,912	1,891	17,609	11,062	6,547
International migration	45,591	5,554	2,661	2,892	40,037	19,608	20,430
Medicare-based estimates	22,956	1,943	719	1,225	21,013	8,901	12,111

Notes: Estimates may not sum to totals shown because of rounding. Black AOIC refers to Black alone or in combination with other races. All others are classified as non-Black alone or in combination. The deaths component includes deaths to Armed Forces overseas and deaths to the native resident population. Net international migration includes the international migration of both native and foreign-born populations. Specifically, it includes: (a) the foreign born, (b) the net international migration of the native born, (c) the net migration between the United States and Puerto Rico, and (d) the population born abroad of U.S. citizen parents living in the United States on April 1, 2020.

Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).

Table 5. Population Estimates and the Components Used to Construct the U.S. Resident Population by Sex and Hispanic Origin for Ages 0 to 29: April 1, 2020 (In thousands)

Series and Component	Total Population	Hispanic			Non-Hispanic		
		Both Sexes	Male	Female	Both Sexes	Male	Female
Low Series							
Total population	127,337	29,264	14,978	14,286	98,073	50,011	48,062
Births	120,298	25,668	13,092	12,576	94,630	48,466	46,163
Deaths	1,386	235	132	103	1,151	702	449
International migration	8,425	3,831	2,018	1,813	4,594	2,247	2,347
Middle Series							
Total population	127,844	31,439	16,109	15,329	96,405	49,160	47,245
Births	120,298	27,486	14,016	13,470	92,812	47,542	45,270
Deaths	1,386	235	132	103	1,151	702	449
International migration	8,932	4,188	2,225	1,963	4,744	2,320	2,424
High Series							
Total population	128,202	33,344	17,086	16,259	94,857	48,365	46,492
Births	120,298	29,235	14,911	14,324	91,063	46,647	44,416
Deaths	1,386	235	132	103	1,151	702	449
International migration	9,290	4,345	2,306	2,038	4,945	2,420	2,525

Notes: Estimates may not sum to totals shown because of rounding. The deaths component includes deaths to Armed Forces overseas and deaths to the native resident population. Net international migration includes the international migration of both native and foreign-born populations. Specifically, it includes: (a) the foreign born, (b) the net international migration of the native born, (c) the net migration between the United States and Puerto Rico, and (d) the population born abroad of U.S. citizen parents living in the United States on April 1, 2020.

Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).

Table 6. Overview of the Assumptions used to Develop the Low Series of the 2020 Demographic Analysis Estimates			
Cohorts Born from 1945 to 2020			**Cohorts Born Before 1945**
Births	**Native Deaths**	**International Migration**	**Ages 75 and Over (Medicare)**
Corrections for birth registration completeness are reduced by 30 percent in the number of births added to the official registered total Race for Black alone/non-Black alone estimates is assigned by adjusting the middle series downward by one mean absolute deviation derived from the Both Parent, Kidlink, and Mother Rule race assignment methods Race for Black AOIC/non-Black AOIC estimates is assigned by adjusting the middle series downward by one mean absolute deviation derived from the Minority Rule, Kidlink, and Father Rule race assignment methods Births to Hispanic mothers are assigned Hispanic, while all others are non-Hispanic	Infant deaths corrected for under-registration through 1959	Foreign-born Stock Method with no adjustment for coverage of the foreign-born population in the ACS Net Native-born Migration produced using census, survey, and population register data from other countries with a 10% deflation from the middle series Net Migration from Puerto Rico developed using Residence One Year Ago (ROYA) method with data from ACS and PRCS Born Abroad of U.S. Citizen Parents developed using historical data and ACS stock data	No adjustment for under-enrollment in the Medicare records No Medicare component for the Hispanic origin estimates
Notes: Some components only had one version that was used for the low, middle, and high series: native deaths, Armed Forces overseas, deaths to Armed Forces overseas, Puerto Rico migration, and the population born abroad of U.S. citizen parents. Acronyms in this table include: American Community Survey (ACS) and Puerto Rico Community Survey (PRCS).			
Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).			

Table 7. Overview of the Assumptions used to Develop the Middle Series of the 2020 Demographic Analysis Estimates			
Cohorts Born from 1945 to 2020			**Cohorts Born Before 1945**
Births	**Native Deaths**	**International Migration**	**Ages 75 and Over (Medicare)**
Corrections by race applied to registered NCHS births for 1936 to 1985 derived from 1940, 1950, and 1964 Birth Registration Tests (BRTs) and later adjustments to the correction factors from previous DA programs Race for the Black alone/non-Black alone estimates is assigned using Kidlink proportions Race for the Black AOIC/non-Black AOIC is assigned using Kidlink proportions Hispanic origin is assigned using Kidlink proportions	Infant deaths corrected for under-registration through 1959	Foreign-born Stock Method with adjustment for coverage of the foreign-born population in the ACS Net Native-born Migration produced using census, survey, and population register data from other countries Net Migration from Puerto Rico developed using Residence One Year Ago (ROYA) method with data from ACS and PRCS Born Abroad of U.S. Citizen Parents developed using historical data and ACS stock data	Adjustment for under-enrollment in the Medicare records made using the low unenrollment factors calculated from the 2019 5-year ACS data No Medicare component for the Hispanic origin estimates
Notes: Some components only had one version that was used for the low, middle, and high series: native deaths, Armed Forces overseas, deaths to Armed Forces overseas, Puerto Rico migration, and the population born abroad of U.S. citizen parents. Acronyms in this table include: National Center for Health Statistics (NCHS), American Community Survey (ACS), and Puerto Rico Community Survey (PRCS).			
Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).			

Table 8. Overview of the Assumptions used to Develop the High Series of the 2020 Demographic Analysis Estimates			
Cohorts Born from 1945 to 2020			**Cohorts Born Before 1945**
Births	**Native Deaths**	**International Migration**	**Ages 75 and over (Medicare)**
Corrections for birth registration completeness are increased by 30 percent in the number of births added to the official registered total Race for Black alone/non-Black alone estimates is assigned by adjusting the middle series upward by one mean absolute deviation derived from the Both Parent, Kidlink, and Mother Rule race assignment methods Race for Black AOIC/non-Black AOIC is assigned by adjusting the middle series upward by one mean absolute deviation derived from the Minority Rule, Kidlink, and Father Rule race assignment methods Hispanic births are identified by the Minority Rule, while all other births are non-Hispanic	Infant deaths corrected for under-registration through 1959	Foreign-born Stock Method with coverage adjustments from the middle series inflated by 2.5% Net Native-born Migration produced using census, survey, and population register data from other countries with a 10% inflation from the middle series Net Migration from Puerto Rico developed using Residence One Year Ago (ROYA) method with data from ACS and PRCS Born Abroad of U.S. Citizen Parents developed using historical data and ACS stock data	Under-enrollment factors calculated using the 2019 5-year ACS data were inflated by 5% No Medicare component for the Hispanic origin estimates
Notes: Some components only had one version that was used for the low, middle, and high series: native deaths, Armed Forces overseas, deaths to Armed Forces overseas, Puerto Rico migration, and the population born abroad of U.S. citizen parents. Acronyms in this table include: American Community Survey (ACS) and Puerto Rico Community Survey (PRCS).			
Source: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release).			