Economic Commission for Europe

Conference of European Statisticians

Work Session on Demographic Projections

Belgrade, 25–27 November 2019
Item No. 9 of the provisional agenda
Assumptions on Mortality

U.S. Census Bureau's Domestic and International Population Projections: Current Approaches to Mortality Projections

Note by the U.S. Census Bureau*

Summary

The Population Division of the U.S. Census Bureau is responsible for developing estimates and projections of the population of the United States. It also prepares estimates and projections of the populations of countries throughout the world, which are available online through its International Data Base. This presentation provides an overview of the approaches and software tools used to make population projections, with a focus on mortality projections.

The 2017 National Population Projections are the latest series of population projections for the United States. Mortality is projected through a three-step process of projecting life expectancy at birth to 2100 to select model life tables, using the model life tables to project mortality rates to 2100, and finally by creating life tables for the projection period. This series includes the first mortality projections to account for the generally lower mortality rates and longer life expectancy of the foreign born in the United States. Nativity is incorporated into mortality projections using information from death certificates regarding the country of birth of the deceased. This method improvement allows us to more accurately project native and foreign-born populations in the United States.

For international projections, life expectancy by sex in each country is projected to improve in line with worldwide historical trends and upper asymptotes of life expectancy (e.g., a fixed logistic model) as well as an associated "ultimate" life table. The projections of such improvement are currently being extended to the year 2100. International projections are performed using the DAPPS (Demographic Analysis and Population Projection System) software application, developed by the Census Bureau. Key advantages of DAPPS are: 1) easy entry of the projection components, 2) easy development of high/low or other desired variants, 3) demographic analysis features to refine estimates from the original inputs, and 4) facilitation of subnational projections, the aggregation of which can be controlled to the national projection in each year.

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I. Introduction

1. The U.S. Census Bureau produces projections of the United States population using a cohort-component method and assumptions about demographic components of change (future trends in births, deaths, and net international migration). Projections are updated periodically to incorporate revised assumptions about anticipated trends and updated data for these components. This can result in differences between series in the projected population, both in terms of number and in distribution across characteristics. This paper describes the methodology and assumptions for the mortality inputs used to produce the 2017 National Population Projections.

2. The United States has long been an immigrant destination, which has implications for mortality projections because the foreign born typically have lower mortality rates and live longer, on average, than people who were born in the United States. In 1960, the foreign born accounted for only 5.4 percent of the population. By 2010, they represented 12.9 percent (Grieco, et al., 2012), a figure that is projected to grow to 17.1 percent by 2060. This mortality trend is widespread and extends to foreign-born groups from different countries and socioeconomic backgrounds (Mehta, et al., 2016). By accounting for the mortality differences of the foreign born, we can create more accurate projections of the U.S. population as a whole.

3. In addition to domestic projections, the Census Bureau also produces estimates and projections of the populations of countries throughout the world, which are available online through its International Data Base (IDB). Mortality projections incorporate a fixed logistic pattern based on worldwide mortality trends. The projections are in the process of being extended from 2050 to 2100.

II. Domestic Projections: Projecting Mortality by Nativity, Race, and Hispanic Origin

4. The Census Bureau has produced population projections by race since 1948 and by nativity since 2014. The 2017 National Population Projections were the first to account for the generally lower mortality rates and longer life expectancy of the foreign born in the United States. Nativity is incorporated into mortality projections using information from death certificates regarding the country of birth of the deceased.

A. Data and Methods

5. The denominators used to calculate mortality rates were derived from the intercensal estimates for the years 1990 to 2009, and the Vintage 2016 population estimates for 2010 to 2015. To create a consistent time series of estimates by the required characteristics, we had to adjust for changes in the way that race has been measured in vital records and in the population data from 1989 to the present. Intercensal estimates were available only by four races prior to 2000 (White, Black, Asian and Pacific Islander (API), and American Indian and Alaska Native (AIAN)). For the period from 2000 to 2015, estimates were produced for a total of 31 race groups consistent with the revised Office of Management and Budget (OMB) standards for data on race and ethnicity (United States Census Bureau, 2018). Similarly, death records contain race reported in the four groups for all years of the time series, 1989 through 2015, and in the 31 race groups for select states and years starting in the early 2000s. To maintain continuity of the population estimates across the time series, and consistency between the population estimates and vital records, bridged race population estimates were used for 2000 to 2015[1].

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[1] Bridged race estimates are those where multiple-race responses are converted back to the single-race categories consistent with the 1977 OMB standards for data on race and ethnicity.

6. The Census Bureau's population estimates do not distribute the population on the basis of nativity. To calculate population estimates by nativity, we applied proportions of native and foreign-born populations within age, race, and Hispanic origin groups from the 1990 and 2000 Decennial Censuses and the 2001 to 2015 single-year ACS files to the estimates for those years[2]. Annual estimates of the resident population by nativity were not available for the period from 1991 to 1999. To create population estimates by nativity for these years, the proportion of the native population was linearly interpolated between the 1990 and 2000 censuses. Computed proportions were then applied to the population estimates to fill in the missing values. After these adjustments, we had final denominators which consist of population estimates by age, sex, race, Hispanic origin, and nativity from 1990 to 2015.

7. Mortality rates were calculated from death registration data for 1989 to 2014 from the National Center for Health Statistics (NCHS). In conjunction with population estimates from 1989 to 2014 – discussed in the denominator section above – death data were used to produce a series of mortality rates by age, sex, race, Hispanic origin, and nativity. Death data include four categories of race (White, Black, American Indian and Alaska Native, and Asian and Pacific Islander), two categories for Hispanic origin (Hispanic and non-Hispanic), and two categories for nativity (native and foreign born). Deaths to non-residents were excluded from the series[3].

8. Due to concerns about the quality of race reporting in the death data over the time series, non-Hispanic race groups with similar mortality patterns were collapsed into two categories. As a result, mortality rates were produced for three race and Hispanic origin groups: (1) Non-Hispanic White, Asian, and Native Hawaiian or Other Pacific Islander, (2) non-Hispanic Black and American Indian or Alaska Native, and (3) Hispanic (of any race). Nativity of the deceased was incorporated into this projection series by creating a dichotomous variable that distinguished deaths to native residents from deaths to residents who were foreign-born. Native deaths are those to individuals born in the United States or in U.S. territories, while foreign-born deaths are those to individuals born elsewhere.

B. Projecting Mortality

9. Mortality was projected in three steps: 1) Project life expectancy at birth (e0) by sex to the year 2100 to determine which model life tables will be used to project mortality rates; 2) Project mortality rates to the year 2100; 3) Create life tables for the years 2017 through 2060 using the projected mortality rates.

10. Life expectancy at birth (e0) was projected indirectly using the log of the complement of life expectancy at birth for the years 2000 through 2014. We assumed the upper limit for e0 to be 100, therefore, the complement was calculated as 100 minus e0 for a given year. The log of the complement of life expectancy at birth was projected to the year 2100 using linear extrapolation and was converted back to e0, giving us 87 years for males and 91 years for females in 2100. Consequently, we selected the United Nations (UN) Model Life Tables with e0 of 87 years for males and 91 years for females as the ultimate targets that we would use to project mortality rates.

11. To project the mortality rates, we merged the UN model life table rates with the 2014 mortality rates by sex and single year of age. We used the natural logs of the 2014 and target mortality rates to interpolate values for 2017 through 2060 that were then converted back to rates. This method produces a non-linear progression over time that places faster rates of change at the beginning of the period and very small rates of change toward the end of the period.

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[2] The universe represented by the ACS varies across years. For instance, in the years 2000 to 2004, data are available only for areas with populations greater than 250,000, whereas in the years 2005 and beyond, data are available for populations in excess of 65,000. For detailed descriptions of the ACS data, see https://www.census.gov/acs/www/.

[3] Non-residents are defined as persons whose reported state of residence is not one of the 50 states or the District of Columbia.

12. Complete life tables, including survivorship ratios, were then produced from the mortality rates for 2017 through 2060. The survivorship ratios from these life tables for ages 0-99 were applied to the population in the projections to calculate deaths (deaths for ages 1 and over are equal to the difference between the population alive at the start of a given time interval and survivors to the end of that interval). The survival ratio representing the population 100 years and older was split into single years of age and extended to age 115. Survivorship rates were linearly interpolated from age 100 to age 115, where the survivorship for age 115 was set to 0 under the assumption that no individuals in the projection survive beyond that age.

1. Results

13. Figure 1 shows projections of life expectancy at birth by sex, nativity, and race and Hispanic origin groups. Life expectancy is shown for 2017 and 2060 and the bubble sizes represent the gain in life expectancy from 2017 to 2060. For males and females, life expectancy at birth is lowest for people who are non-Hispanic Black and American Indian or Alaska Native, regardless of their nativity. The difference in life expectancy at birth is smaller among foreign-born race and Hispanic origin groups compared to the native race and Hispanic origin groups, meaning native-born groups tend to be more dispersed than foreign born groups in figure 1. Despite having the lowest projected life expectancies at birth from 2017 through 2060, people who are non-Hispanic Black and American Indian or Alaska Native are projected to experience a larger increase in life expectancy during this time than any of the other groups. Between 2017 and 2060, life expectancy at birth for the native non-Hispanic Black and American Indian or Alaska Native group is anticipated to increase by about 10 years for males and 8 years for females. The projected increase in life expectancy is smaller for their foreign-born counterparts.

Figure 1. Life Expectancy at Birth: 2017 and 2060
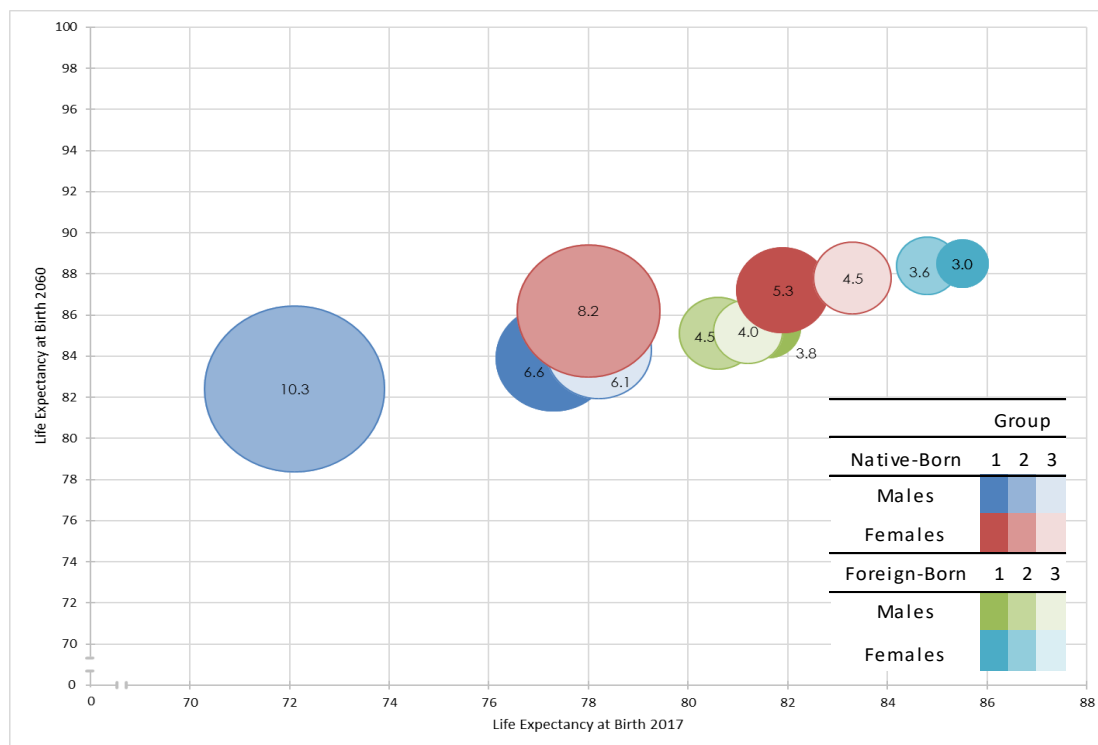
Note: Group 1 represents Non-Hispanic White, Asian, and Native Hawaiian or Other Pacific Islander; Group 2 represents Non-Hispanic Black or African American and American Indian or Alaska Native; Group 3 represents Hispanic.

Note: Size of the bubble represents the number of years in life expectancy gained between 2017 and 2060.

Note: The bubbles overlap for foreign-born females groups 1 and 3.

Source: U.S. Census Bureau, 2017 National Projections.

14. Table 1 shows life expectancy at birth by nativity, sex, race, and Hispanic origin over time from 2017 to 2060. Foreign-born race and Hispanic origin groups had higher life expectancies at birth in 2017 compared to each of their native counterparts. Foreign-born Non-Hispanic White, Asian, andNative Hawaiian or Other Pacific Islanders as well as foreign-born Hispanic females, are projected to have the highest life expectancies at birth throughout the projected period. In 2017, they were tied for the highest life expectancy at 85.5 years. All groups are projected to gradually increase in life expectancy between 2017 and 2060.

Table 1. Life Expectancy at Birth by Nativity, Sex, Race, and Hispanic Origin: 2017 to 2060

Year	Male			Female		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Native born						
2017	77.3	72.1	78.2	81.9	78.0	83.3
2020	77.9	73.0	78.7	82.3	78.7	83.6
2030	79.6	75.8	80.4	83.7	80.9	84.8
2040	81.2	78.3	81.8	85.0	82.9	85.9
2050	82.6	80.5	83.1	86.1	84.6	86.8
2060	83.9	82.4	84.3	87.2	86.2	87.8
Foreign born						
2017	81.6	80.6	81.2	85.5	84.8	85.5
2020	81.9	81.0	81.6	85.7	85.1	85.8
2030	82.9	82.2	82.6	86.4	86.0	86.5
2040	83.8	83.3	83.6	87.1	86.9	87.2
2050	84.6	84.3	84.4	87.8	87.7	87.9
2060	85.4	85.1	85.2	88.5	88.4	88.5

Note: Group 1 represents Non-Hispanic White, Asian, and Native Hawaiian or Other Pacific Islander; Group 2 represents Non-Hispanic Black or African American and American Indian or Alaska Native; Group 3 represents Hispanic.

Source: U.S. Census Bureau, 2017 National Projections.

III.   International Projections

15. International estimates of mortality are based on the most reliable sources of data available for each country (or area), which may include vital registration, censuses, surveys, and/or other sources. International projections of mortality from recent estimated levels assume fixed logistic improvements in line with historical patterns of countries with higher life expectancies, combined with a presumed upper limit. Although future crossovers in life expectancy no doubt will occur between certain countries, these simplifying assumptions typically prevent them. The presumed upper limit of life expectancy by sex is in the process of being raised by about a dozen years above current assumptions (likely to about 100 for females and 95 for males), and the projection horizon is being extended from 2050 to 2100. Such updates and extensions will bring the upper limits of mortality for international projections closer in line to those assumed by the Census Bureau for the United States itself. The ultimate life table (age pattern) of mortality by sex is also being updated based on a model life table matched to presumed life expectancies. These modifications and extensions are expected to be incorporated into country projections on the IDB (see Census Bureau, 2019).

16. The process of updating and extending IDB projections of mortality (and other demographic parameters) is facilitated by DAPPS (Demographic Analysis and Population Projection System), a software application developed by the Census Bureau. DAPPS combines demographic analysis features (such as population age smoothing, indirect estimation, and assessment of net census errors by age and sex) with cohort-component projections. This software is freely available for download at the Census Bureau's website (https://www.census.gov/data/software/dapps.html).

17. Among the most valuable features of DAPPS is its ability to perform and organize subnational projections (e.g., for geographic units one level below the national—provinces, states etc.). Once a national projection has been determined, a feature in DAPPS allows a user to force the sum of its subnational projections to match the national cohort-component projection in every year. This feature utilizes the outputs from all of the respective projections, from which algebraic adjustments are made to each of the subnational projections in order to match the national projection.

IV.   Conclusion

18. The Population Division of the U.S. Census Bureau produces population projections for the United States and for other countries around the world. The procedures for projecting mortality are not entirely the same for the United States and other countries, but the latest updates and extensions on the international side will bring the ultimate assumed levels closer together.

V.   References

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