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Methods to Create Monthly Population Estimates for Provisional Vital Statistics

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Abstract

Background: Timely and detailed population estimates are necessary for the production and dissemination of accurate provisional birth and death rates from the National Vital Statistics System. Publicly available monthly population estimates do not align with the annual population estimates used to calculate official birth and death rates based on final data.

Objective: To create monthly state-level population estimates by age, sex, and race/ethnicity consistent with the vintage-specific annual population estimates published each year by U.S. Census used to produce birth and death rates.

Data source: Vintage-specific annual July population estimates by state, age, sex, and race/ethnicity from the U.S. Census population estimates program, from 2010 through 2025.

Methods: For months from July 2010 through July 2025, cubic spline interpolation was used to provide a smooth set of population counts by state, age group, sex, and race/ethnicity. Interpolated monthly counts from January 2020 through July 2025 were used to fit a set of linear regression models by group and predict population counts for the months after July 2025 (August 2025 through December 2026) by linear extrapolation.

Results: Monthly population estimates align with the July annual vintage-specific population counts used in the production of official birth and death rates, and these methods can be used to provide additional geographic, demographic, and temporal detail in provisional population-based birth and death rates.

Primary use case: Monthly population estimates by age, sex, race/ethnicity, and state can be used for provisional birth and death rates in the Vital Statistics Rapid Release Program.

Introduction

Annual population estimates from the U.S. Census Population Estimates Program (1) are used as denominators to produce mortality rates (2) and birth rates (3) by state, age, sex, and race/ethnicity. Each year, the Census Population Estimates Program produces a new vintage of these annual population counts, and the National Vital Statistics System uses the vintage corresponding to a given final data year to produce official final statistics. For example, final birth rates and mortality rates for 2024 (2,3) used the 2024 Vintage annual population estimates (1).

Quarterly provisional estimates of birth rates (4) and mortality rates (5) rely on Census monthly population counts for the midpoint of each quarter, which are only published by age, sex, and race/ethnicity for the United States overall (6). These monthly postcensal estimates provide a consistent series from 2020 through the vintage year. For example, vintage 2025 provides monthly estimates from 2020 through 2025, with short-term projections for 2026 (6). However, there are a few limitations of the monthly postcensal estimates for the purposes of estimating provisional birth and death rates in near-real time. First, the monthly postcensal estimates often do not align with the annual vintage-specific population estimates used to produce final birth and death rates in prior years. For example, the July 2021 population estimate from the 2025 vintage monthly postcensal estimates (the most current series available) is 332,100,166, compared with the vintage 2021 July estimate used for final birth and death rates of 331,893,745. Although the difference is typically small in percentage terms for the total US population, the magnitude of the difference can vary across smaller subgroups when estimating rates by age, sex, and race/ethnicity. This can contribute to potential discrepancies between provisional and final estimates based on different denominators even when the numerators (i.e., births or deaths) remain the same. Second, there can be abrupt changes between the intercensal (2010 to 2020) and the postcensal (2020 and later) series, which can create sharp increases or decreases in birth or death rates driven by the shift in population denominators. Third, monthly estimates are not published by age, sex, and race/ethnicity at the state or county level, limiting the availability of more geographically granular population denominators for estimating state or even county-level birth and death rates. Finally, although the monthly postcensal series include short-term projections for the post-vintage year, there is often a delay in data availability, potentially limiting the timeliness of provisional birth and death rates released through the Vital Statistics Rapid Release program.

Monthly state-level population estimates by age, sex, and race/ethnicity, based on the vintage-specific annual population estimates (1), could improve the timeliness, granularity, and consistency of provisional birth and death rates with final rates.

Data

Annual vintage-specific July 1 population estimates from 2010 through 2025 were downloaded from the Census website (7). These tables provide US resident population counts as of July 1 of each year by state, single year of age, sex (male or female), and race/ethnicity (American Indian or Alaska Native, non-Hispanic; Asian, non-Hispanic; Black, non-Hispanic; Hispanic; More than one race, non-Hispanic;

Native Hawaiian or Other Pacific Islander, non-Hispanic; White, non-Hispanic). Single year of age was combined into five groups: 0–19 years, 20–39 years, 40–59 years, 60–79 years, 80 years and older to assess patterns broadly by age group.

Methods

To generate monthly state-level population estimates by age group, sex, and race/ethnicity, annual vintage-specific population estimates from 2010 through 2025 were used, which include July 1 estimates for each year. For months between July 2010 and July 2025, cubic spline interpolation (8) was used to provide a smooth set of monthly population counts by state, age group, sex, and race/ethnicity. Cubic spline interpolation connects each annual July estimate with a smooth curve. While spline models can be prone to overfitting, the purpose here was not to estimate the true underlying trend in population counts, but to provide a smoothed set of estimates that align with the vintage-specific annual estimates used in the production of official final birth and death statistics. In some cases, using new vintage-specific population estimates each year can create sharp increases or decreases in annual population counts. Because true population changes are expected to be gradual (based on largely stable rates of change for deaths, births, and migration), smooth trends provided by cubic spline interpolation are more realistic representations of this gradual change in population counts compared with carrying forward population counts from each vintage through the next year, which would create a stepped pattern over time. Smooth trends also help avoid sharp changes in population-based rates (e.g., mortality rates or birth rates) that can appear as an artifact of updating to a new vintage or series.

Interpolated monthly counts from January 2020 through July 2025 were used to fit a set of linear regression models by group and predict population counts for the months after July 2025 (August 2025 through December 2026) by linear extrapolation (9). These estimates represent short-term linear projections of monthly population counts by group based on the linear trends from January 2020 through July 2025. Spline models were not used for extrapolations, because they can be overly sensitive to changes in trend at the end of the time period, resulting in inappropriate extrapolations where the rate of change can be extreme (10). Using linear extrapolation based on data from the last five years is a straightforward approach that is more robust to recent fluctuations in population counts.

All analyses were conducted in R (9). The ‘zoo’ package was used for cubic spline interpolation (8) and the ‘stats’ package was used for linear extrapolation (9). Code to replicate the analysis is available on GitHub [https://github.com/CDCgov/MonthlyPopulationDenominatorEstimates/].

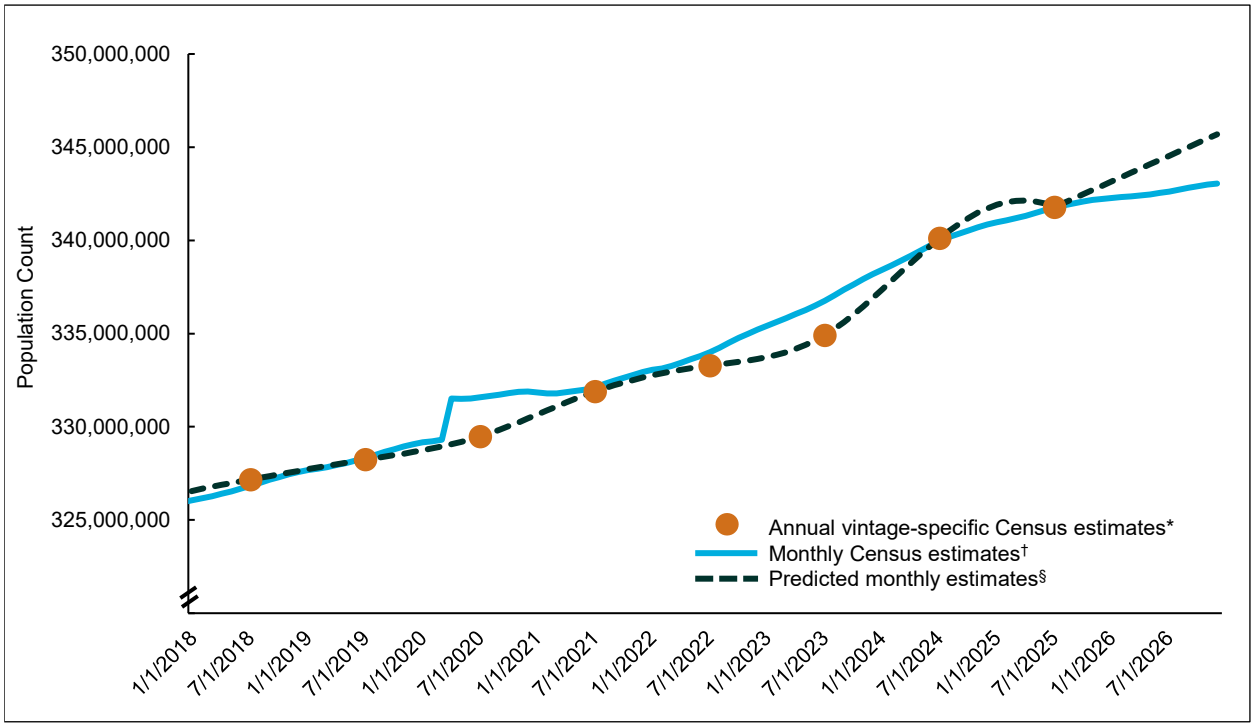
Results

Interpolated and predicted monthly population counts provided a smooth trend over time and aligned better with vintage-specific annual population counts than the Census monthly population estimates (Figure 1). Monthly Census population estimates (6) deviated from the vintage-specific annual Census population estimates, and discrepancies varied by year, with larger differences in 2020 and 2023 than other years. By contrast, the predicted monthly population counts provide a smooth line between annual vintage specific estimates. Because the predicted monthly population estimates rely on cubic spline interpolation prior to July 2025 and linear extrapolation for August 2025 and later, there is a

discrete shift in the trends from July 2025 to August 2025. However, by construction, the predicted monthly estimates are consistent with the vintage-specific annual Census estimates.

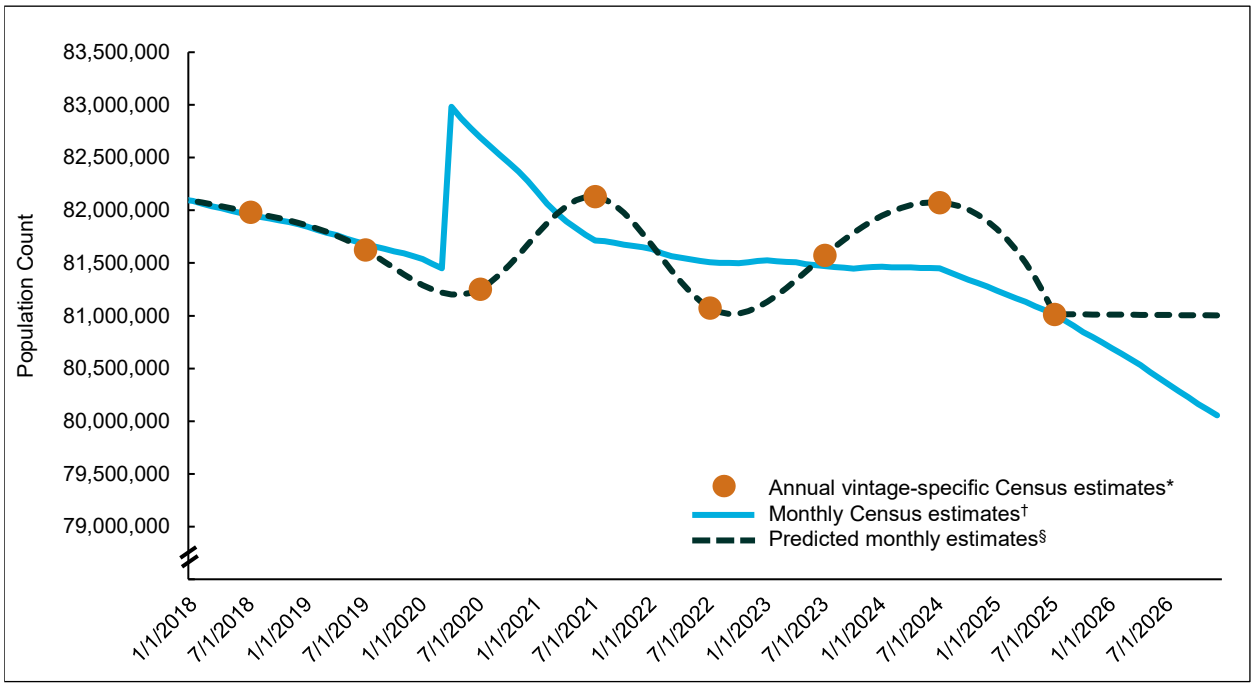
Comparisons of estimates by age group (0–19 years, 20–39 years, 40–59 years, 60–79 years, 80 years and older) are shown in Figures 2–6.

Figure 1. Comparison of monthly population estimates by source, United States, 2018-2026



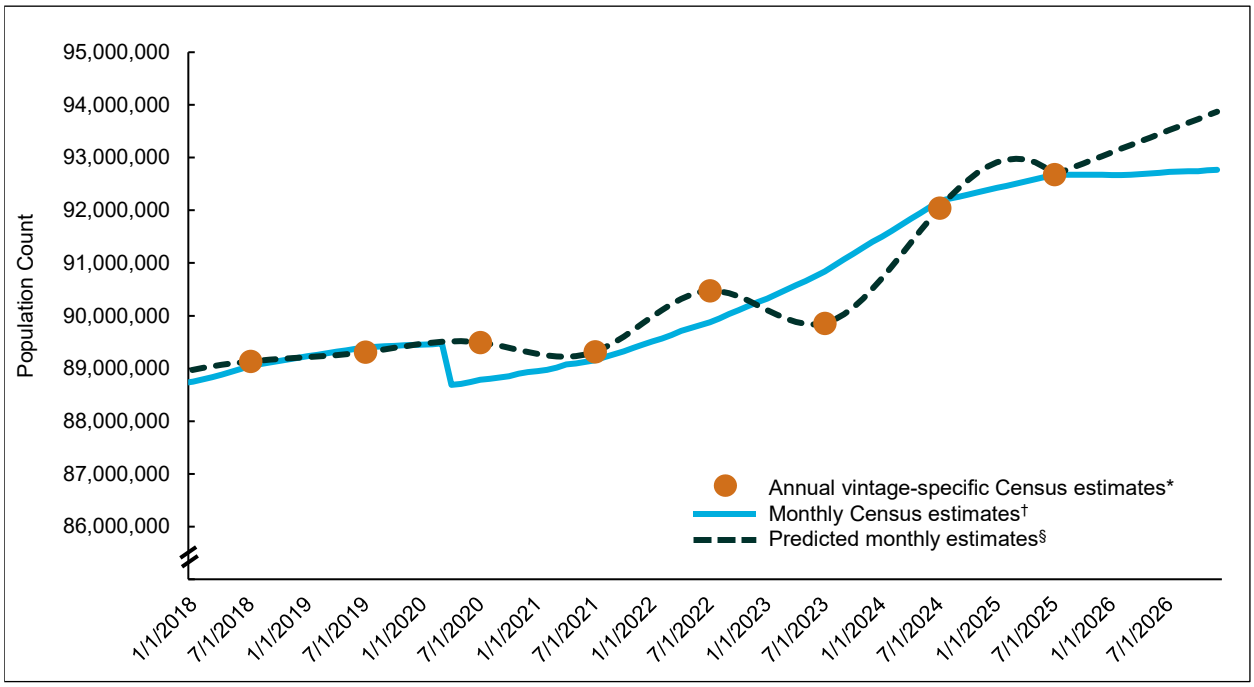
* Annual vintage-specific population estimates from the Census Population Estimates Program.
† Monthly population estimates from the Census Population Estimates Program.
§ Predicted monthly population estimates based on cubic spline interpolation (January 2018—July 2025) and linear extrapolation (August 2025—December 2026).
SOURCE: National Center for Health Statistics, Vital Statistics Rapid Release program. 2026.

Figure 2. Comparison of monthly population estimates by source, United States, 2018-2026: Ages 0-19 years



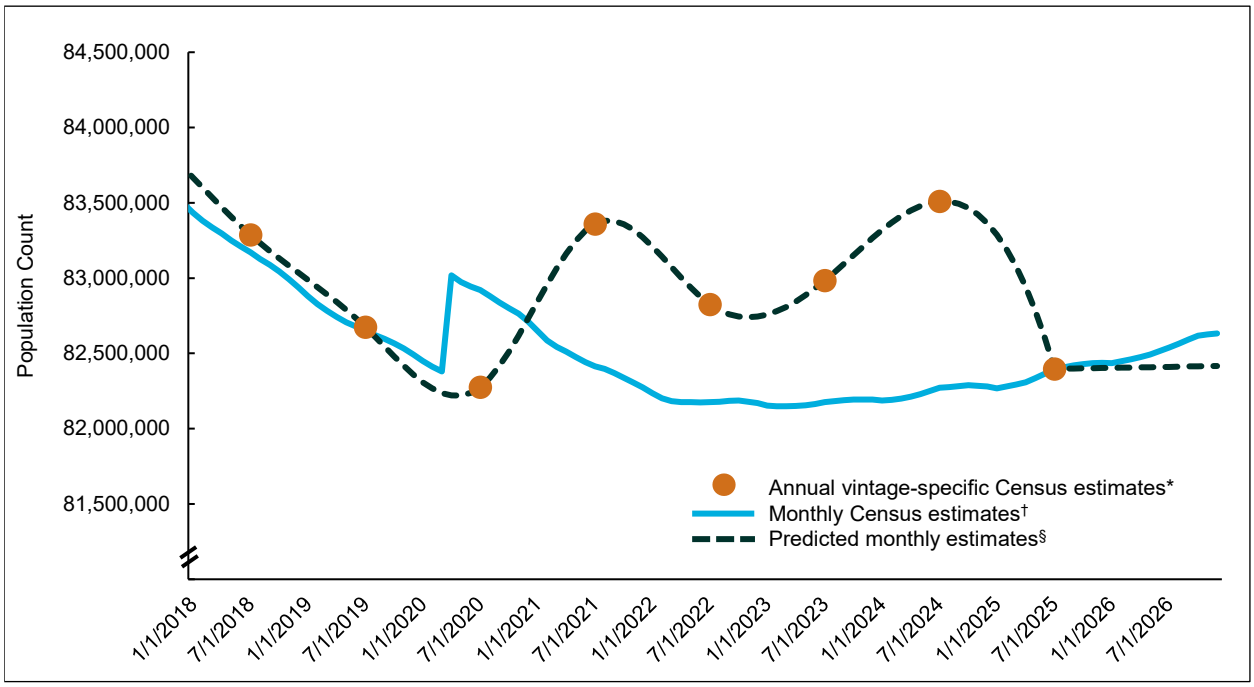
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§ Predicted monthly population estimates based on cubic spline interpolation (January 2018—July 2025) and linear extrapolation (August 2025—December 2026).
SOURCE: National Center for Health Statistics, Vital Statistics Rapid Release program. 2026.

Figure 3. Comparison of monthly population estimates by source, United States, 2018-2026: Ages 20-39 years



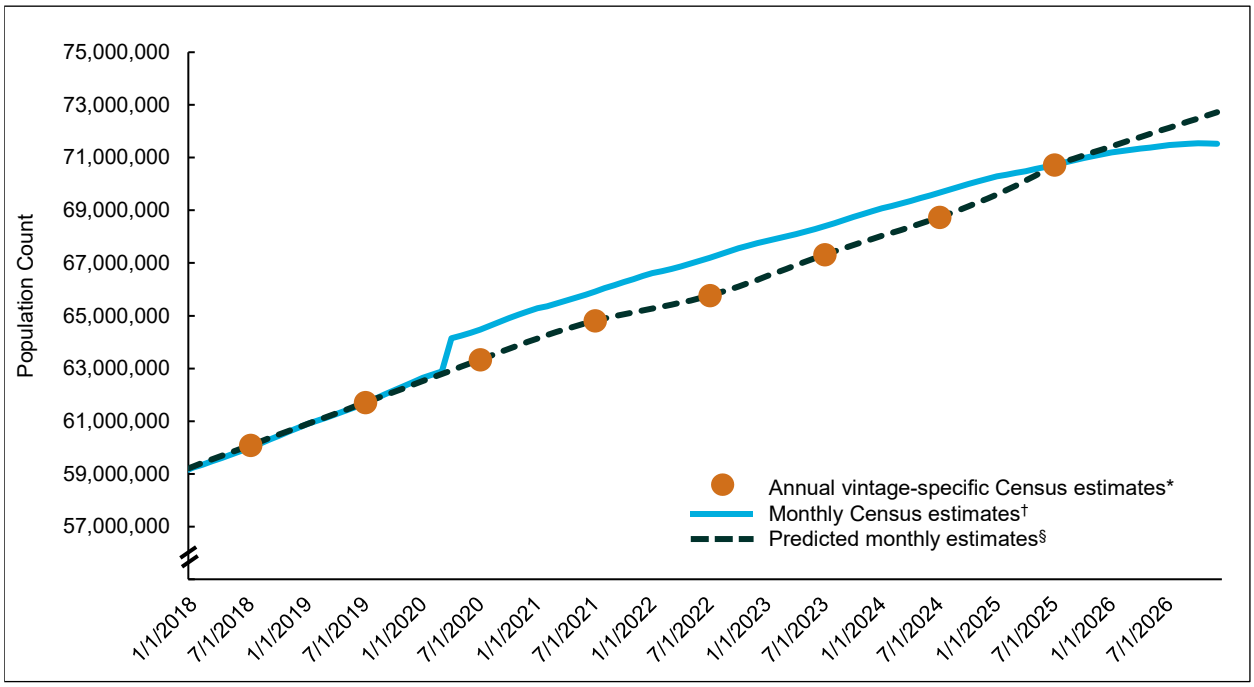
* Annual vintage-specific population estimates from the Census Population Estimates Program.
† Monthly population estimates from the Census Population Estimates Program.
§ Predicted monthly population estimates based on cubic spline interpolation (January 2018—July 2025) and linear extrapolation (August 2025—December 2026).
SOURCE: National Center for Health Statistics, Vital Statistics Rapid Release program. 2026.

Figure 4. Comparison of monthly population estimates by source, United States, 2018-2026: Ages 40-59 years



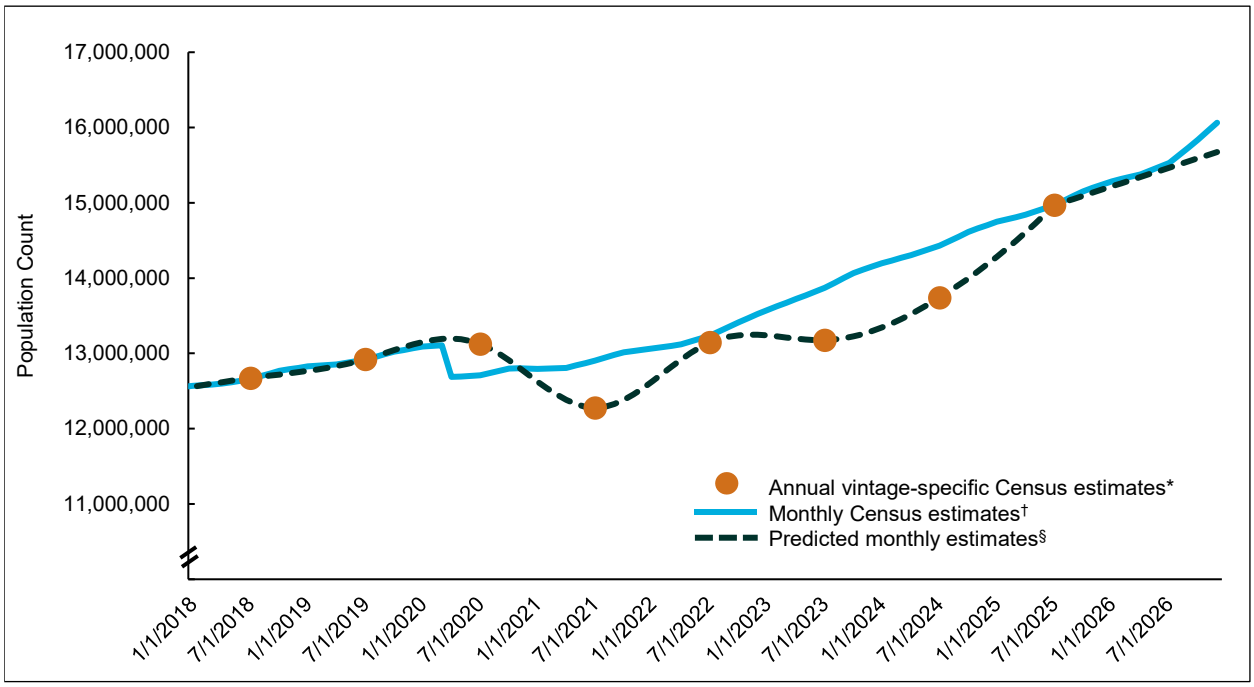
* Annual vintage-specific population estimates from the Census Population Estimates Program.
† Monthly population estimates from the Census Population Estimates Program.
§ Predicted monthly population estimates based on cubic spline interpolation (January 2018—July 2025) and linear extrapolation (August 2025—December 2026).
SOURCE: National Center for Health Statistics, Vital Statistics Rapid Release program. 2026.

Figure 5. Comparison of monthly population estimates by source, United States, 2018-2026: Ages 60-79 years



* Annual vintage-specific population estimates from the Census Population Estimates Program.
† Monthly population estimates from the Census Population Estimates Program.
§ Predicted monthly population estimates based on cubic spline interpolation (January 2018—July 2025) and linear extrapolation (August 2025—December 2026).
SOURCE: National Center for Health Statistics, Vital Statistics Rapid Release program. 2026.

Figure 6. Comparison of monthly population estimates by source, United States, 2018-2026: Ages 80 years and over



* Annual vintage-specific population estimates from the Census Population Estimates Program.
† Monthly population estimates from the Census Population Estimates Program.
§ Predicted monthly population estimates based on cubic spline interpolation (January 2018—July 2025) and linear extrapolation (August 2025—December 2026).
SOURCE: National Center for Health Statistics, Vital Statistics Rapid Release program. 2026.

Discussion

Estimated monthly population estimates by age, sex, and race/ethnicity, based on vintage-specific annual population estimates, can provide additional geographic and demographic detail for provisional population-based rates, reduce discrepancies between provisional and final birth and mortality rates driven by the use of different population denominators and improve the timeliness of provisional estimates. The methods described here also allow for future extensions to generate monthly population denominators for provisional birth and death rates by additional levels of geography (e.g., state, county) or demographic detail (e.g., race/ethnicity, urban-rural residence).

Limitations

The methods described here have several limitations. First, there are still potentially non-smooth changes in trend from prior to July 2025 to August 2025 and later. These changes in trend are more evident for some groups than others (e.g., ages 0—19 years and 40—59 years). Second, population change in recent years may be non-linear and could potentially be better characterized by using non-linear models rather than linear extrapolation. Linear extrapolation is a simpler approach and avoids inappropriate extrapolations that spline-based models can suffer from where the rate of change at the end of the time series can be implausibly large or small. Finally, the vintage-specific population estimates are not the most up-to-date estimates released by Census. Each new vintage includes

updated estimates for prior years. The 2025 vintage used a different base population source than prior vintages, along with incorporating other methodological updates (11). These methodological changes may contribute to differences in estimates between vintages from 2024 and earlier relative to 2025 and later. While estimates from the 2025 vintage for 2020—2025 are methodologically consistent, the vintage-specific estimates are the population estimate source used in the production of official annual birth and death statistics; as such, these estimates were used to reduce discrepancies between provisional and final birth and death rates.

Conclusion

Monthly population estimates were generated that align with those used in producing official birth and death rates, and to provide additional geographic, demographic, and temporal detail for provisional population-based birth and death rates. The methods used here reduce potential discrepancies between provisional and final birth and mortality rates that can arise due to the use of different population denominators and support the timely release of provisional data. Future refinements of these methods may provide additional detail by geography or demographic group. Additionally, comparisons of projected counts with official counts eventually published by Census will inform further development of modeling approaches.

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