UMASS DONAHUE INSTITUTE

Section IV. Technical Discussion of Methods and Assumptions

excerpt from:

Long-term Population Projections for Massachusetts Regions and Municipalities

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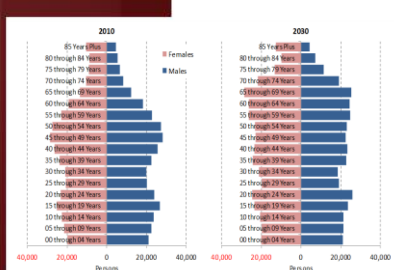

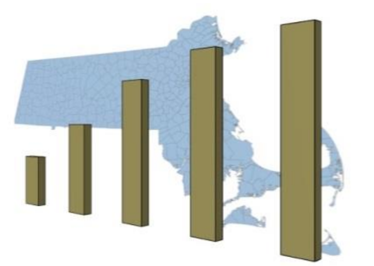

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IV. Technical Discussion of Methods and Assumptions

This section provides a technical description of the process used to develop the 1) regional and 2) municipal-level population projections using a cohort component approach. While both levels of projections are prepared using a cohort component method, the major methodological difference is in the way migration is modeled: the municipal-level estimates (also referred to as Minor Civil Divisions, or MCDs) rely on residual net migration rates computed from vital statistics, while the sub-state regional projections use gross domestic migration rates based on the American Community Survey Public Use Microdata (ACS PUMS). MCD projections are controlled to the eight regions' projections in order to smooth out variations due to data quality issues at the MCD level and ensure more consistent and accurate projections at higher-level geographies. These controlled MCD projections can then be re-aggregated to other areas of interest, such as counties, regional planning areas, etc.

A. Regional-Level Methods and Assumptions

Summary

This section describes the process and data used to develop the regional population projections. These projections were developed separately for eight regions, although each region was produced following a generally similar framework. The methodology describing how the regional projections were used to estimate municipal population projections follows in Part B of this section.

Our regional projections are based on a demographic accounting framework for modeling population change, commonly referred to as a cohort-component model. The cohort-component method recognizes that there are only four ways that a region's population can change from one time period to the next. It can add residents through either births or in-migration, or it can lose residents through deaths or out-migration. We further divide migration by whether domestic or international, and use separate estimation methods for each.

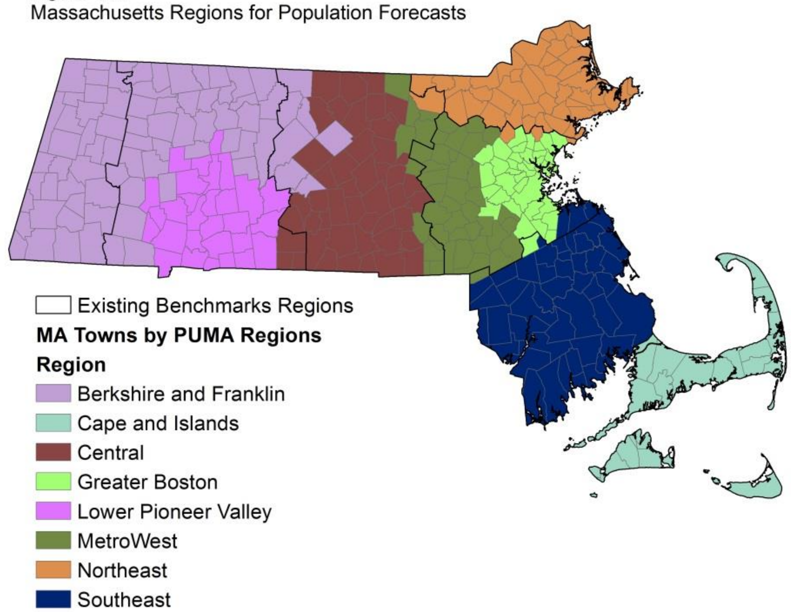
The cohort-component approach also accounts for population change associated with the aging of the population. The current age profile is a strong predictor of future population levels, growth and decline. The age profile of the population can differ greatly from one region to another. For example, the Greater Boston region has a high concentration of residents in their twenties and early thirties, while the Cape and Islands have large shares of near and post-retirement age residents. Furthermore, the likelihood of birth, death, and in- and out-migration all vary by age. Because fertility rates are highest among women in their twenties and early thirties, a place that is anticipating a large number of women coming into their twenties and thirties in the next decade will likely experience more births. Similarly, mortality rates are notably higher for persons seventy years and older, such that an area with a large concentration of elderly residents will experience more deaths in decades to come.

Developing a cohort-component model involves estimating rates of change for each separate component and age-sex cohort (i.e. age-specific fertility rates, survival rates, and in- and out-migration rates) - typically based on recent trends. It then applies these rates to the current age profile in order to predict the likely number of births, deaths, and migrants in the coming years. The changes are added to or subtracted from the current population, with the resulting population aged forward by a set number of years (five years, in our case). The result is a prediction of the anticipated number of people in each cohort X years in the future. This prediction becomes the new starting baseline for estimating change due to each component an additional X years in the future. The process is repeated through several iterations until the final target projection year has been reached.

Regional definitions

A preliminary step in generating our regional projections was to determine the boundaries for each of our study areas. We use the definitions for the MassBenchmarks regions as a starting point. The Benchmarks regions were designed by the UMASS Donahue Institute to approximate functional regional economies (sets of communities with roughly similar characteristics in terms of overall demographic characteristics, industry structure, and commuting patterns). These Benchmarks regions constitute a widely accepted standard among policy officials and analysts statewide that meet common perceptions of distinct regional economies in Massachusetts.

Figure 4.1:
Massachusetts Regions for Population Forecasts



We then compared the Benchmarks regions to the boundaries of Public Use Micro-Sample Areas, also known as PUMAs. PUMAs are the smallest geographic units used by the U.S. Census Bureau for reporting data taken from the detailed (micro) records of the 2005-2009 American Community Survey (ACS) – our primary source of migration data. PUMA boundaries are defined so that they include no fewer the 100,000 persons, and thus their physical size varies greatly between densely settled urban and sparsely settled rural areas. And although PUMAs do not typically match county boundaries, in Massachusetts individual PUMAs can be grouped together to form regions whose outer boundaries match aggregated groups of individual municipalities. This critically important feature allows us to match Census micro-data with other Census data and State vital statistics estimates we obtained at the municipal level (i.e. births and deaths). We performed our regional grouping using Geographic Information System mapping software. The resulting study regions are presented in Figure 4.1.

Estimating the components of change

Determining the launch year and cohort classes

We begin by classifying the composition of resident population into discrete cohorts by age and sex. Following standard practice, we use five year age cohorts (e.g. 0 to 4 years old, 5 to 9,… 80 to 84, and 85 or older) and develop separate profiles for males and females, based on information provided in the 100% Count (SF 1) file of the 2010 Decennial Census of Population. This will also serve as the starting point (i.e. launch year) for generating forecasts.

Deaths and Survival

The first component of change is survival. Our projections require an estimate of the number of people in the current population who are expected to live an additional five years into the future. Estimating the survival rate of each cohort is fairly straightforward. The Massachusetts Department of Public Health provided us with a detailed dataset that included all known deaths in the Commonwealth that occurred between 2000 to the end of calendar year 2009. This database includes information on the sex, age, and place of residence of the deceased, which we aggregated into our study regions by age/sex cohort. We estimate the five year survival rate for each cohort (j) in study region (i) as one minus the average number of deaths over the past five years (2005 to 2009) divided by the base population in 2005 and then raised to the fifth power, or:

$$Survival\ Rate_{i,j} = \left[1 - \left(\frac{Deaths_{i,j}}{Population_{i,j}}\right)\right]^5. \qquad (1)$$

Following the recommendations of Isserman (1993), we calculate an operational survival rate as the average of the five year survival rates across successive age cohorts. The operational rate recognizes that, over the next five years, the average person will spend half their time in their current age cohort and half their time in the next cohort. We estimate the number of eventual survivors in each cohort by 2015 by multiplying the operational survival rate against the cohort population count as reported by the 2010 Census.

Domestic Migration

Migration is the most dynamic component of change, and often makes the difference between whether a region shows swift growth, relative stability, or gradual decline. Migration is also the most difficult component to estimate and is the most likely source of uncertainty and error in population projections. Whereas fertility and mortality follow fairly regular age-related patterns, the migration behavior of similar age groups is influenced by regional and national differences in socio-economic conditions. Furthermore, the data needed to estimate migration is often restricted or limited, especially for many small areas. Even when it is available, it is based on statistical samples and not actual population counts, and thus is prone to sampling error – which will be larger for smaller regions.

Due to data limitations and the other methodological challenges, applied demographers have developed a variety of alternate models and methods to estimate migration rates. No single method works best in all circumstances, and we evaluated numerous approaches in the development of our projections. Those presented in this report are based on a particularly novel approach known as a multi-region gross migration model as discussed by Isserman (1993); Smith, Tayman and Swanson (2001); and Renski and Strate. Most analysts use a net-migration approach, where a single net migration rate is calculated as the number of net new migrants per cohort (in-migrants minus out-migrants) divided by the baseline cohort population of the study region. Although common, the net migration approach suffers from several conceptual and empirical flaws. A major problem is that denominator of the net migration rate is based purely on the number of residents in the study region. However, none of the existing residents are at risk of migrating into the region – they already live there. While this may seem trivial, it has been shown to lead to erroneous and biased projections especially for fast growing and declining regions.

A gross-migration approach calculates separate rates for in- and out-migrants. Beyond generating more accurate forecasts in most cases, it has an added benefit in that it connects regional population change to broader regional and national forces – rather than simply treating any one region as an isolated area. This type of model is made possible by utilizing the rich detail of information available through the newly released Public Use Micro-Samples (PUMS) of American Community Survey (ACS). The ACS is a relatively new data product of the U.S. Census Bureau that replaced the detailed information collected on the long-form of the decennial census (STF 3). It asks residents questions about where they lived one year prior, which can be used to estimate the number of domestic in- and out migrants. Unfortunately, the ACS does not report enough detail to estimate migration rates by detailed age-sex cohorts in its standard products. This information can be tabulated from the ACS PUMS – which is 5% random sample of individual records taken drawn the ACS surveys. Each record in the PUMS is given a survey weight, which we use to estimate the total number of migrants by detailed age and sex cohorts. It is very important to realize that the PUMS records are based on small, although representative, samples – and that the smaller the sample the greater the margin of error. Sample sizes can be particularly small when distributed by age and sex cohorts for different types of migrants, especially in small regions.

Estimating domestic out-migration is largely similar to estimating net-migration. Because current residents of the study region (*i*) are those who are 'at risk' of moving out, so the appropriate cohort (*j*) migration rate is:

$$Out\ Migration\ Rate_{i,j} = \left(\frac{OutMigrants_{i,j}}{Population_{i,j}}\right). \qquad (2)$$

Because migration in the ACS is based on place of residence one year prior, the out-migration rate reported in equation (2) is the equivalent of a single year rate. We multiply this by five to estimate the five-year equivalent rate, and, as we did with survival rates, average the five year rates across succeeding cohorts to craft an operational five year rate.[1] The operational rate for each cohort is then multiplied against the number of eventual survivors in 2015 to estimate the number of likely out-migrants from the surviving population.

In-migration is more challenging. The candidate pool of potential domestic in-migrants is not those currently living in the region, but people living elsewhere in the U.S. Modeling in-migration thus requires collecting data on the age-sex profile of not only the study region, but for other regions as well. We model two separate regions as possible sources of incoming migrants in the multi-regional framework - those originating in neighboring regions and states (New York, Connecticut, Rhode Island, New Hampshire, and other Massachusetts regions) and those coming from elsewhere in the U.S. By doing so, we recognize that most inter-regional migration is fairly local and that the migration behavior of the Northeast is likely to differ considerably from that of the rest of the nation – in part due to our older and less racially diverse demographic profile.

Thus the in-migration rates characterizing migration behavior from neighboring regions (NE) to study region (i) and from the rest of the United States (U.S.) are calculated as:

$$In\ Migration\ Rate_{NE\ to\ i,j} = \left(\frac{InMigrants_{NE\ to\ i,j}}{Population_{NE,j} - Population_{i,j}}\right) \tag{3}$$

$$In\ Migration\ Rate_{US\ to\ i,j} = \left(\frac{InMigrants_{US\ to\ i,j} - InMigrants_{NE\ to\ i,j}}{Population_{US,j} - Population_{NE,j}}\right). \tag{4}$$

As with the out-migration, each single-year in-migration rate is converted into a five-year operational migration rate. Unlike out-migration, these in-migration rates are not multiplied against the surviving regional population for the study region but instead the cohort population for the region of origin (neighboring regions for equation 3 or the rest of the U.S. for equation 4) to reflect the true population at risk of in-migration. The data for estimating the launch year cohort size for other regions is aggregated from the 2010 Census of Population (SF 1), with the study region cohort population subtracted from the base of neighbor regions and neighbor populations subtracted from the United States cohort population.

International Migration (immigration and emigration)

One quirk of the ACS is that while it does contain information on the residence of recent international immigrants, it contains no information that might be used to estimate emigration. This is because the ACS only surveys people currently living in the U.S. This includes recent immigrants, but not people that moved out of the nation during the last year.

There is no consensus on how best to deal with emigration. Writing in the era when immigration statistics came from the Decennial Census and were based on a five-year rate, Isserman (1993) argues that emigration can be safety ignored. In part, this is because emigration for most areas is typically very small. He also argues that since emigrants are not surveyed in the Census (they

[1] This differs from calculating the five-year survival rate, where the one-year rate was taken to the fifth power. Survival is modeled as a non-recurring probability, since you can only die one. However, we assume that any individual migrant could move more than once during the study period, and multiply the single year rate by five to estimate a five-year equivalent.

already left the region), so technically they are not counted in the population at risk - i.e. smaller denominator), there would be no resulting bias. However, this is less true for ACS-based surveys because they are estimated as multi-year rolling surveys with a single-year migration question. A person surveyed in year 1 could technically out migrate in years 2 – 5, and therefore international emigration may be undercounted if ignored. The large numbers of foreign students that attend college and university in some regions make underestimated emigration issues far from trivial and might well overstate future growth.

A second problem is that there are often very few international immigrants included in the ACS PUMS for some sex-age cohort combinations. This is especially problematic for smaller regions and among elderly cohorts where people tend to be less mobile. The result in such places might be wildly erratic estimates of immigration.

We take two different approaches to estimating the international migration component, depending upon the size of the study region. For large regions, we estimate international immigration directly based on information reported in the ACS PUMS files – ensuring that there was a sufficient number of sample points in each cohort. We do not estimate emigration directly, but rather indirectly adjust for emigration using the survival/residual method that will be discussed shortly. We distinguish large regions as those with populations in excess of one million persons in 2010. This includes the Greater Boston, Northeast, and Southeast regions. In the case of the five remaining small regions (under 1 million) we provide no direct estimates of either immigration or emigration, but use the survival/residual approach to the estimate both missing components.

The survival/residual approach uses the basic population change accounting framework of the cohort-component model coupled with data from the recent past to estimate the change attributable to the missing component(s). For us, the missing components are international net migration (immigration – emigration) for small regions, and international emigration for large regions. Consider the case of the small region, where the change in population between two intervals (say 2005 and 2010) can be described as:

$$Population_{2010} - Population_{2005} = Births - Deaths + InMigrants - OutMigrants + Immigrants - Emmigrants + \epsilon \tag{5}$$

where *InMigrants* and *OutMigrants* represent domestic migration only. Births, deaths, and domestic in- and out- migration are estimated for the historical period (2005 to 2010). The unknown component is net international migration (immigrants – emigrants) plus any error associated with imprecision in the population counts or other components of change – most likely from sampling error in the measurement in domestic migration. By re-arranging (5) we can isolated the unknown component, resulting in:

$$Immigrants - Emmigrants + \epsilon = Population_{2010} - (Population_{2005} + Birth - Deaths + InMigrants - OutMigrants) \tag{6}$$

In other words, we simply make a prediction of what the population should have been in 2010 if the 2005 population changed only according to births, deaths, and net domestic migration. We then subtract the predicted value from the actual (observed) population in 2010. This residual can be attributed to population change associated with the missing components and historic forecast error. This process must be completed for each separate cohort, noting that births are only relevant to estimating population change in the first (zero to five year-old) cohort and the deaths and migration data should be averaged over succeeding cohorts to account for the amount of time spent in each cohort over a five year interval (the equivalent of calculating an operational rate).

For forecasting future population levels, the estimated residual component must first be converted into the form of a rate and then applied to the appropriate 'at risk' population. Because the residual is a composite (net migration plus error) and there is no reliable source of information on the population 'at risk' in this instance, we instead divide the residual by the study region population in each cohort for the base year (2005 in this case). The result is a ratio of the size of the residual to the size of the cohort, and not a true rate. This residual ratio is then multiplied against the expected surviving population for each cohort to generate an estimate of the residual component. It is worth noting, that calculating a residual component in this manner has the practical effect of partially 'constraining' future population growth to rates close to those in the recent past. This means that if the projected growth without the residual component is much greater than what actually occurred, the residual rates will tend to be negative, and the future level of growth will be reduced. Conversely, if the unadjusted model under-predicted population levels in the recent past the residual rates would trend positive - thus accelerating growth over the level predicted by observable factors.

The final step of the migration model adds the estimated net number of domestic migrations (in-migrants minus out-migrants) and the estimated residual component (i.e. net international migration + error) to the expected surviving population in order to estimate the expected number of "surviving stayers." This is an estimate of the number of current residents who neither die nor move out of the region in the coming five years, plus any new migrants to the region. These surviving stayers are then used as the basis for estimating anticipated births.

Births and Fertility

The final component requires estimating fertility rates using past data on the number of live births by the age of the mother. Like survival, information on births comes from the Massachusetts Department of Public Health which was aggregated, by region, into our five-year age cohorts according to the mother's age, and averaged over five years (2005-09). The number of births is then divided by the corresponding number of women in 2005 for each cohort to generate an approximate age-specific fertility rate. The births of males and females are modeled separately in our approach, however in both cases it is the only the number of women in each cohort that represents the population 'at risk' and appears in the denominator of the fertility rate. This single year fertility rate is multiplied by five to estimate a five-year equivalent, or:

$$Fertility\ Rate_{i,j} = 5\left[\left(\frac{Births_{i,j}}{Number\ of\ Women_{i,j}}\right)\right]. \tag{7}$$

Next, the estimated fertility rates are multiplied against the number of females in the child-bearing age cohorts among the number of 'surviving stayers' as estimated in the previous step. This provides an estimate of the number of babies that are anticipated within the next five years, and this number is summed across all maternal age cohorts.

Aging the population and generating projections for later years

The final step in generating our first set of five year forecasts (for year 2015) is to age the surviving stayers in all cohorts by five years. The first (0 to 4) and final (85+) cohorts are treated differently. The number of anticipated babies estimated in the previous step becomes the number of 0 to 4 year olds in 2015. The number of persons in the 85+ cohort in 2015 is the number of surviving stayers in the 80 to 84 age cohort (in 2010) added to the number of surviving stayers in the 85 and older cohort. As we made separate estimated for males and females the two populations are added and summed across all cohorts to determine the projected number of residents in 2015.

This process is essentially repeated for all future year projections, except that the rates developed from historic data remain the same throughout the forecast horizon. Our 2015 projection becomes our launch year population for estimating the 2020 population, which in turn is used to seed the 2025 population and so-forth. The only notable difference in the process used to generate the later year forecasts is the need to have outside projections of future population levels for the nation as a whole and for neighboring states. This is necessary for estimated the population 'at-risk' of domestic in-migrants. The U.S. Census Bureau regularly generates highly detailed national population forecasts.[2] We use the latest release of national forecasts (release date May, 2013) which are based on information from the 2010 Decennial Census. Unfortunately, the Census Bureau no longer generates detailed state-level long-term projections. Lacking a better source, we use the final set of Census-based state projections (release date 2005) for estimating future in-migrants from neighboring states. In future updates, we hope to either develop or acquire more updated state-level projections.

[2] http://www.census.gov/population/projections/

B. Municipal-Level Methods and Assumptions

MCD-Level Model Overview

As described in the regional-level methods section of this report, separate projections are produced for the 351 MCDs and for the eight state sub-regions. The MCD results are then controlled to the corresponding projected regional cohorts to help smooth any inconsistences in the MCD-level results and to reflect migration trends that may be more accurately reflected by the regional projection methodology.[3] While both of the regional and MCD-level projections are prepared using a cohort component method, the MCD estimates rely on residual net migration rates computed from vital statistics, while the sub-region projections use gross domestic migration rates based on the American Community Survey Public Use Microdata (ACS PUMS).

The population age 5 and over is projected by the mortality and migration methods, while the population age 0-4 is projected by the fertility method. The initial launch year is 2010, with projections made in five-year intervals from 2015 to 2030 using the previous projection as the new launch population. Projections for seventeen five-year age groups (0-4, 5-9 …80-84, and 85+) are reported for males and females. (Throughout this document, the term "age" refers to a 5-year age cohort). The cohort component method is used to account for the effects of mortality, migration, and fertility on population change.

Population projections for each age and sex cohort for each five-year period are created by applying a survival rate to the base population, adding net migration for each age/ sex/ MCD cohort, and finally adding births by sex and mother's age, as shown in the table below.

Component	Projection
Mortality	Survived population by age/sex
Migration	Net migration by age/sex
Fertility	Births by sex and mother's age
Launch	2010 Census count by age/sex for 2015 projection; Five-year projection thereafter

Data Sources

The launch populations by sex, age cohort, and MCD were obtained from U.S. Census 2010 data. UMDI estimated population by age and sex for 2005 from the 2000 and 2010 U.S. Censuses using a simple linear interpolation by age and sex.

[3] The regional projection methodology, discussed at length in Section IV.A. of this report, projects domestic migration using migration data from the American Community Survey, therefore explicitly accounting for recent domestic migration trends. As explained in this section, the MCD methodology uses a "residual" method based on vital statistics to project migration.

UMDI requested and received confidential vital statistics data for births and deaths from January 1, 2000 through December 31, 2009 from the Massachusetts Department of Public Health. From these, UMDI estimated survival, birth and residual net migration rates.

MCD Projections Launch Population

Initial Launch Population

The initial launch population for the 2015 projection is the 2010 Census population by age/sex for each MCD. Corrected census counts from the Count Question Resolution (CQR) program are incorporated where applicable. Each projection thereafter uses the previous projection as the launch population (i.e. the 2020 projection uses the 2015 projection as the launch population).

MCD Projections: Mortality

Forward Cohort Survival Method

The forward cohort survival method is used to account for the mortality component of population change. This procedure applies five-year survival rates by age/sex to the launch population by age/sex for MCDs in order to survive their populations out five years, resulting in the expected population age five and over before accounting for migration.

5-Year Survival Rates by Age/Sex

UMDI calculated five-year survival rates by age and sex using deaths by age, sex and MCD from 2000 to 2009 (January 1, 2000 through December 31, 2009). Survival rates by age, sex and MCD were assumed to be constant for the duration of the projections (from 2010 through 2030). Survival rates for each age cohort up to 80-84 were averaged with the next-older cohort to account for the fact that roughly half of each cohort would age into the next cohort over the course of each 5-year period. The 85+ cohort's survival rate was used as-is, since there was no older cohort to average.

MCDs with smaller populations demonstrated a degree of variability in survival rates that we considered too broad for optimal results. Therefore, for MCDs with populations lower than 10,000 as of the 2000 Census, we used regional survival rates by age and sex instead of MCD-specific rates to smooth the results. We calculated regional rates using the same MCD-based vital statistics data from 2000-2009 as we used in calculating the MCD rates.

Survived Population for MCDs

The base population by age/sex for MCDs is survived to the next 5-year projection by applying the corresponding averaged five-year survival rates by age/sex.

Lag in Death Data

For each current vintage, vital statistics data showing deaths will only be available for past years – for instance, in producing the Vintage 2013 estimates (the first vintage), we have death data only through 2009.

Key Assumptions

The methodology assumes that survival rates vary most significantly by age and sex. To some extent, the use of MCD-specific rates will also indirectly account for varying socioeconomic factors, including race and ethnicity, which vary by MCD and may affect survival rates. The methodology assumes that survival rates by age, sex and MCD will stay constant over the next 20 years.

<u>MCD Projections: Migration</u>

Residual Net Migration from Vital Statistics

The residual net migration method is used to account for the migration component of population change. “Residual” refers to the fact that migration is assumed to be responsible for past population change after accounting for births and deaths. This residual net migration is then used to estimate past migration rates. The procedure applies the resulting net migration rates by age/sex estimated for each MCD to the MCD’s survived population by age/sex in order to project net migration by age/sex for the population age 5 and over. For the population ages 0-4, it is assumed that residence of infants will be determined by the migration of their birth mothers. For MCDs with 2000 Census population below 10,000, a linear migration assumption (described below) is used to smooth migration.

Determination of Net Migration Rates

Vital statistics are used to infer net migration totals for 2000-2009. In order to calculate five-year net migration by age, sex and MCD, natural increase (births minus deaths) by age/ sex for 2000-2005 is added to the 2000 population by age/ sex for each MCD, and then the results are subtracted from the interpolated 2005 population by age/ sex for each MCD to estimate net migration by age/ sex and MCD for 2000-2005. A similar process calculates migration between 2005 and 2010.

For MCDs with 2000 population equal to or greater 10,000, the two five-year net migration estimates are averaged and rates are then calculated for each age, sex and MCD. The resulting rates are applied to the base population to project five-year net migration. The resulting average five-year net migration rates by age/sex are held constant throughout the projection period.

For MCDs with 2000 population under 10,000, five-year net migration by age, sex and MCD is held constant, and population cohorts are never allowed to go below zero. This avoids applying unrealistically high migration rates to small populations. For instance, if an MCD starts with 4 males aged 70-74 and net migration shows 4 more move in over five years, the result is a migration rate of 2. This results in highly variable and unrealistic results in some cases. . In this example, holding migration linear means that in each five-year projection period, four males aged 70-74 will move into the MCD. UMDI conducted sensitivity testing for this method and found that the model with constant migration for small places in most cases resulted in more realistic, gradual population growth or decline, as well as more realistic sex and age profiles for these MCDs.

Key Assumptions

The use of a net migration rate relies on a base for migration that includes only current residents – in other words, only those at risk of out-migration. Nonresidents who are at risk of in-migration are not explicitly accounted for in the MCD method, and this results in some inaccuracy which is minimized by the process of controlling to regional total projections that are based on a gross migration model.

We assume that age, sex and MCD are the key factors by which migration rates vary. Other factors, including non-demographic factors such as macroeconomic factors, or local policy changes, are not explicitly included in this model. Future projections models may incorporate these or other factors.

Fertility

Vital Statistics Method

We apply age-specific fertility rates to the migrated female population by age to project births by age of mother, followed by survival rates for the population aged 0-4. Total survived births are then derived by summing across all maternal age groups, and the results represent the projected population age 0-4. For each MCD, the number of males and females is assumed to be the same as the proportion of male or female births statewide.

Fertility by Age of Mother

Average births by age of mother for each MCD are calculated for two five-year periods (2000-2005 and 2005-2010) using nine maternal age groups, from 10-14…50-54.

Fertility Rates

Age-specific fertility rates are computed for each time period by dividing the average number of births by age of mother by the corresponding number of females of that age group. The average age-specific fertility rates are held constant throughout the projection period. The base population for launching a new five-year projection is the survived, post-migration projected female population by age.

MCDs with smaller populations demonstrated a degree of variability in fertility rates that we considered too broad for optimal results. Therefore, for MCDs with populations lower than 10,000 as of the 2000 Census, we used regional fertility rates by age and sex instead of MCD-specific rates to smooth the results. We calculated regional rates using the same MCD-based vital statistics data from 2000-2009 as we used in calculating the MCD rates.

Lag in Birth Data

For each current vintage, birth data will only be available for past years – for instance, in producing the Vintage 2013 estimates (the first vintage), we have birth data only through 2009.

Key Assumptions

We assume age, sex and MCD to be adequate indicators of fertility rates for MCD for the first vintage projections. We assume that the proportion of male to female births does not vary significantly by geography or maternal age. We assume that fertility rates by maternal age and MCD will not change significantly over time. Future iterations of the projections may amend these assumptions based on available data.

<u>Controlling to the Regional-level Projections</u>

The resulting MCD-level projected cohorts are finally controlled to the regional-level projected cohorts. To do this, we assume that each MCD's share of the region's population, for each age and sex cohort, is given by the MCD population projections. Those shares are then applied to the regional projections to arrive at adjusted age/ sex cohorts for each MCD.

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