Regional Population Projections for Japan: 2015–2045
Overview of the Method
(Released in 2018)

Introduction

We publicized the new population projection by region in March 2018. We projected population by age, sex, and municipalities of Japan, except the municipalities in Fukushima Prefecture. Due to the Fukushima Daiichi nuclear disaster triggered by the 3/11 Great East Japan Earthquake in 2011, it remains troublesome to foresee geographical patterns of future resident mobility and vital statistics in Fukushima Prefecture. Therefore, for Fukushima Prefecture, we decided to make use of the total prefectural population of municipalities as a single projection unit.

Before 2010, the National Institute of Population and Social Security Research had organized three separate population projection projects corresponding with three levels of geographical aggregation: all Japan, prefectures, and municipalities. On the release of *The Population Census of Japan*, the series of population projections begins with national projection, followed by prefectural and municipal projections. However, the impacts of the Great East Japan Earthquake on reproduction and migration behaviors were extensively outspread over municipalities. Hence, following the release of the population projection for Japan based on the 2010 Population Census, we conducted population projections for municipalities first, and we obtained the future prefectural populations by aggregating the population projections for municipal residents belonging to respective prefectures. In this regional population projection for municipalities and prefectures as a part of the 2015 round projections, we adopt the approach of the 2010 round. Note that the totals by age and sex of populations in geographical units reported here are consistent with the medium-variant fertility and medium-variant mortality projection results of the national projections (published in 2017).

This paper summarizes the projection method and its implementation (i.e., details in assumption settings). We acknowledge that we utilized statistical tables prepared with the secondary use of questionnaire information collected for *The Vital Statistics of Japan* under Article 32 and Article 33 of the Statistics Act No. 53 of May 23, 2007.

An Overview of the Projection Method

1. Projection Horizon and Interval

The projection will be conducted every five years for 30 years, starting with 2015 and ending with 2045.

2. Target Municipalities and Prefectures of the Projection

The geographical units subjected to the projection included 1,798 municipalities (23 Tokyo special wards, 128 wards in 12 major cities, 766 cities, 713 towns, and 168 villages), within the boundaries as of March 1, 2018, and one prefecture (Fukushima). As noted above, the projection for Fukushima Prefecture was not conducted by municipalities but only prefectural population was projected; as a consequence of the Fukushima Daiichi nuclear disaster triggered by the Great East Japan Earthquake, the future municipal patterns of population in Fukushima Prefecture are too uncertain to make a projection. The 12 major cities, whose wards were taken as the projection unit, were identified by the availability of data required for the projection. These cities were Sapporo (Hokkaido), Sendai (Miyagi) Chiba (Chiba), Yokohama (Kanagawa), Kawasaki (Kanagawa), Nagoya (Aichi), Kyoto (Kyoto), Osaka (Osaka), Kobe (Hyogo), Hiroshima (Hiroshima), Kitakyushu (Fukuoka), and Fukuoka (Fukuoka), with the name of the respective prefecture in parentheses.

3. The Method

A variant of the cohort component method was adopted for the projections. The cohort component method calculates future population by applying future vital rates to an age-specific population in a certain year. In the implementation of this method for the projection of the population of the age group 5 and above, survivorship rates and migration rates are required. For the projection of the population of age group 0–4, the cohort component method requires future age-specific fertility rates and future sex ratios at birth, in addition to survivorship and migration rates. However, because municipal-level annual fertility rates fluctuate, we accommodated a child-woman ratio and a sex ratio of the population of the age group 0–4. Hence, our projection requires 1) initial populations and making assumptions for four sets of age- and sex-specific demographic rates, 2) future survivorship rates, 3) future migration rates, 4) future child-woman ratios, and 5) future sex ratios of the population of the age group 0–4.

Note that the initial projection results produced using the future demographic rate assumptions were adjusted so that the sums of populations by age and sex in geographical units conformed to age- and sex-specific populations in the national projection results (medium fertility and medium mortality). We report these adjusted municipal populations, whose total is consistent with the national projection results (medium fertility and medium mortality), as the final results in this paper. Figure 1 (at the end of this document) summarizes this projection procedure in a flowchart.

4. Initial Population

The initial population used as the base for the projection included total population – both Japanese nationals and foreigners – by five-year age group, sex, and municipality as of October 1, 2015, according to "The Population of Nationality- and/or Age-Unknown Adjusted Population" in the *2015 Population Census of Japan* (the Statistics Bureau, Ministry of Internal Affairs and Communications)[1]. Note that the projection for Fukushima Prefecture considered prefecture as a single projection unit, so the prefectural population in the census report was used as the base for Fukushima Prefecture.

5. Setting Future Age-specific Survivorship Rates

In order to reflect the future direction of the national projection's survivorship-rate assumptions (the case of medium mortality) (i.e., national tendency of improvements in life expectancy) on regional mortality, we employ a measure called relative disparity, a ratio of regional survivorship rates to the national rates. By the relative disparity, we set future survivorship rates for each region as moving the same direction as the future national levels. Note that, throughout this paper, we refer to the ratio of regional measures to that of broader area (i.e., the ratio of survivorship rates at the prefectural level to that of the national level and also the ratio of the survivorship at the municipal level to that of the prefectural level) as a relative disparity or often simply as a disparity[2].

For the age groups 55–59→60–64 and below, because regional differentials in mortality among municipalities are limited, we set future survivorship rates by prefecture and applied them to municipalities within each prefecture. Specifically, by using *The Prefectural Life Tables 2010* and *The Prefectural Life Tables 2015* (Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare), the lifetable survivorship ratios by the age group, sex, and prefecture

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[1] Somusyo Toukei-kyoku, *Heisei-27-Nen Kokusei-chosa no Nenrei・Kokuseki Husyo wo Anbun-shita Jinko(Sanko-hyo)* (https://www.stat.go.jp/data/kokusei/2015/kekka/anbun.html: access on December 19, 2018). This population is the base for *The Population Estimates* conducted by the Statistics Bureau. Basically, the population with unknown nationality and/or age was proportionately distributed to every group of Japanese/foreigners and five-year-olds by living condition and sex within each municipality. By considering living condition, the procedure clarified whether the population with unknown nationality/age lived alone or not. After the adjustment was made by municipalities, prefectural populations were obtained by aggregating the total populations of respective municipalities. Also, see *The Outline of the Population Estimates* (https://www.stat.go.jp/english/data/jinsui/1.html: accessed on December 19, 2018).

[2] As we adjusted municipal projection results obtained by mechanical calculation using future vital rates to be consistent with the national projection result (published in 2017), we utilized the relative disparity in order to set these future vital rates consistent with those of the national projection. For example, suppose age- and sex-specific survivorship rate of a region was 20% lower than that of all Japan, say 0.08 and 0.1, respectively, and the national survivorship rate will improve 10% thus decreasing to 0.09 in future. Then, if we set and keep the relative disparity constant at 0.8, we have the future survivorship rate of the region at 0.072 calculated by a multiplication of the relative disparity (0.8) and the rate of change for the national survivorship rate (0.9).

for the period 2010–2015 were calculated. Then, the relative disparity of the prefectural survivorship rates to that of the national level was calculated by the age group and sex for each prefecture. These relative disparities were assumed to diminish linearly, such that the disparities in the period 2040–2045 would reach half the corresponding levels of the disparities in the period 2010–2015.

For the age groups 60–64→65–69 and above, since municipal differentials for mortality in each prefecture are sizeable to the extent of significantly affecting the results of population projections, we utilized the relative disparities of municipal survivorship rates to the respective prefecture's survivorship rate. Specifically, the life table survivorship ratios by the age group, sex, and municipality for the period 2000–2010 were calculated by using nLx functions in *The Municipal Life Tables 2000*, *The Municipal Life Tables 2005,* and *The Municipal Life Tables 2010* (Ministry of Health, Labour and Welfare). Meanwhile, survivorship ratios of prefectures were calculated based on *The Prefectural Life Tables 2000*, *The Prefectural Life Tables 2005,* and *The Prefectural Life Tables 2010*. Then, the relative disparities between municipal survivorship rates and the rates of respective host prefectures were computed using these figures. Similar to the method employed in setting survivorship rates for the age groups 55–59→60–64 and below, we set future municipal survivorship rates with the assumption that the relative disparities remain constant between 2000–2010 and 2040–2045.

6. Setting Future Migration Rates by Age and Sex

Inspired by the migration pool model[3], we projected in-migrations and out-migrations by age group, sex, and region separately for future migration. Specifically, for future emigrants we employed age- and sex-specific out-migration probability for each region, which was irrespective of destinations, and was calculated by a certain region's overall out-migrants in a period divided by its residents at the beginning of that period. For future immigrants, we utilized a region's share of immigrants in national totals ("pool") of immigrants by age and sex. Hereafter, we call these rates as the out-migration probability and the share of immigrants as migration rates.

Specific patterns and regularities are not easily conceived for a time series of regional migration rates by age and sex, given that socio-economic conditions of a nation and its regions during each period in time considerably affect the migration behaviors. Hence, in principle, we assumed that the latest patterns of migration rates in the period 2010–2015 would last until the end of the projection horizon.

On the one hand, for the out-migration probability, we use the "Tabulation on Internal

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[3] See, among others, Section 6.5 in Smith, Stanly K., Jeff Tayman, and David A. Swanson, *A practitioner's guide to state and local population projections*, Dordrecht: Springer, 2013.

Migration for Population[4]" from the *2015 Population Census of Japan* by the Statistical Bureau, where age- and sex-specific municipal population based on place of usual residence five years ago by present residence (at the time of the census) was available for population that survived until the time of the census. This table made it possible to identify, for all regions in Japan, the number of out-migrants who lived in a region in 2010, migrated out of the region, and survived until 2015, and we calculated municipal out-migration rates by age and sex based on the out-migrants divided by the 2010 census population. Then, we assumed that the out-migration rates for the period 2010–2015 remained constant until the end of the projection horizon.

On the other hand, regarding the in-migration rate, we first calculated the intercensal estimates of age- and sex-specific in-migrants of all regions using the out-migration rates specified above. For in-migration, we did not directly calculate in-migration rates from the *2015 Population Census*'s tabulation for migration, because there is a significant population whose residence five years before the Census was not reported, especially in regions located in metropolitan areas[5] [6]. Once we had the number of in-migrants for all regions on hand, calculating a region's share of in-migrants was straightforward. We assumed that this share of the in-migrants in the period 2010–2015 remained constant until the end of the projection period[7].

As we set the share of immigrants with reference to the migration pool rather than the traditional net-migration model, we needed to follow the same concept when projecting future population with these migration rates. We first calculated age- and sex-specific out-migrants for all regions by applying the out-migration rates set above to population at the beginning of a period. This gave us "pools" (national totals) of migrants by age and sex, and then we were able to assign age- and sex-specific in-

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4 https://www.e-stat.go.jp/en/statsearch/files?page=1&layout=datalist&toukei=00200521&tstat=000001080615&cycle=0&tclass1=000001093875&tclass2=000001093876&second2=1 accessed on December 20th, 2018.

5 In the 2015 Population Census's tabulation, the proportion of population whose residence five years ago was unknown totaled 8.8% overall for Japan. However, the figure was 23.3% in Tokyo Prefecture.

6 In-migration rates tend to be higher in urban areas, and we do not have more information on whether in-migration rates of the population whose residence five years ago was unknown exceeds those of the population whose residence five years ago was known. We conjecture that using the census tabulation without addressing this issue is likely to be inappropriate.

7 In order to reflect a regional pattern of migration origin-destination combination observed in the 2015 Population Census in setting the future in-migration share, we incorporate multiplicative coefficients of (1) future change in age- and sex-specific population distribution of in-migrant's origins (weighted total of population shares of in-migrant's origins who came to a target municipality by in-migrant distribution of the municipality as a weight) and (2) future change in age- and sex-specific (home) population distribution over regions. The former coefficient becomes greater when population of in-migrant's origin increases.

migrants to each region according to the in-migration share set above. However, due to international migration, national totals of projected population with these in-migrants did not agree with the national projection results, especially in the younger population. Hence, for age groups 55−59→60−64 and below, we projected the age- and sex-specific migrant's "pools," estimated by calculating the difference between the national projection results (including international migrants) and totals of municipal survival populations who had neither died nor migrated.

There are three types of exceptions among regions. First, for municipalities where the migration patterns were significantly altered after the survey for *The Population Census 2015*, we set migration rates reflecting the latest figures. Second, for municipalities where the patterns in the migration rates had deviated from earlier patterns in the period 2010–2015, we made migration assumptions consistent with the past patterns observed in the censuses before 2010 with regard to local conditions. Other than these, for municipalities with small population sizes where migration rates fluctuated, we aggregated the number of migrants (both out-migrants and intercensal estimates for in-migrants) during four periods, from 1995–2000 to 2010–2015, to set the future net migration rates that reflects long-run average levels in the region.

7. Setting Future Child-Woman Ratios

The child-woman ratio (CWR, hereafter) refers to the average population of the age group 0–4 per woman in the age group 15–49 in a region. We utilized age- and sex-specific population from the national projection results (medium fertility and medium mortality scenario) to set the future CWRs by the relative disparities between the municipal CWRs and the national CWR. Specifically, using the *2015 Population Census*, we calculated the CWRs of municipalities and of all Japan, and took the national CWR as the basis for normalizing the municipal CWRs in the form of the relative disparity for an assessment of regional fertility differentials. Next, we set future municipal CWRs with the assumption that relative disparities remained constant from 2015 to 2045 so as regional fertility differentials but future municipal fertility as a whole follows the national change. A similar method was employed for Fukushima Prefecture.

There are a few municipalities where the CWRs deviated in 2015 from the past patterns. For these municipalities, we calculated average CWRs for the period 2000−2015, and set the future CWRs, keeping the average CWRs constant for 2020–2045.

8. Setting Future Sex Ratios for the Age Group 0–4 Population

Sums of male and female populations of the age group 0–4 were projected based on the future CWRs set in the section 7 above. We needed sex ratios for the age group 0–4 population to divide the population into males and females.

For the sake of simplicity, given limited variation in the sex ratio of the youngest population in geographical units, we calculated the sex ratios for the age group 0–4 population from the national projection results (medium fertility and medium mortality scenario) until the end of the projection horizon. Then, we applied the sex ratios of the national average to all municipalities.

Figure 1. Procedure for Regional Population Projection by the Cohort Component Method