GLAINTELLIGENCE

Update 2016-02

GLA Trend-based Projection Methodology

2015 round population projections

July 2016

Introduction

The GLA Demography Team produce a range of annually updated population projections at both borough and ward level for the 33 local authorities in the London region. Each round of projections includes a number of variants designed to meet various user requirements, but in general the variants form two groups:

- Trend projections – those based purely on trends in fertility, mortality and migration,
- Housing-led projections – those which incorporate a forecast housing development trajectory.

This Update is concerned with the development of the GLA trend projection model and the production of the 2015 round of trend-based population projections at borough level. An update presenting the results of these projections is also available.

Note: For clarity this Update refers to mid-year periods by reference to the end year. Therefore the year mid-2001 to mid-2002 is referenced as mid-2002. Similarly, a longer period such as that between mid-2001 and mid-2014 is referenced as mid-2002 to mid-2014.

Development of an expanded cohort component model

The GLA's models and assumptions continue to evolve as new data is released and each new round of projections supersedes earlier rounds. In the case of the 2015 round significant changes have been made to the trend model methodology, particularly in regard to the domestic migration component. The result is a model which accounts for flows between London Boroughs and every other local authority in England, as well as national flows to and from Northern Ireland, Scotland and Wales.

This development has been driven by a desire to better understand the detail within domestic migration flows and has been made possible by the recent release of the Internal Migration back-series by ONS. This dataset makes available local authority to local authority flows by age and sex for the period 2002 to 2014 and therefore provides the data necessary to build an expanded model which fully accounts for domestic migration flows.

The main differences between the 2015 round model and the 2014 round model are as follows:

- Incorporation of the 2014 Mid-year Estimate data on births, deaths, population and international migration.

- Expansion of the model to include data for all local authorities in England as well as Northern Ireland, Scotland and Wales (329 areas). The previous model worked with the 33 London Boroughs plus three regions outside London (36 areas).
- Incorporation of single-year-of-age by sex LA-to-LA flows for the period mid-2002 to mid-2014. This replaces the census-based rates used in previous rounds.
- Incorporation of the mortality trajectory from the 2014 NPP. This replaces the trajectory from the 2012 NPP used in previous rounds.
- The model now generates projected households based on DCLG household formation rates as a standard output. Household projections were previously generated in a separate model after the population projections were complete.

Overview of methodology

These projections are produced using a cohort component projection model. Projections are produced from the starting point of the most recent ONS Mid-Year Estimate (2014).

Each subsequent year's population is generated by the same process, taking the previous year's projected population as the start point. For mid-year to mid-year periods when the total numbers of births, deaths and net migrants are known, the results may be better described as base period estimates.

The cycle of events that takes an initial local authority population and generates a projection of the subsequent year's population is described below and illustrated in the flowchart (Figure 1).

1. The cycle begins with the initial local authority populations by single year of age (0 to 90+) and sex. For the first year, this is the base population, for subsequent years this is the projected population at the end of the previous cycle.

2. The starting population is aged-on and survived to the end of the year by application of age-specific mortality rates.

3. Births are calculated by applying age-specific fertility rates to the female population. As births occur throughout the projection year they are calculated using a combination of the starting and the aged-on and survived female populations at the end of the year.

4. Survival rates are applied to births to project the number that will reach 'age 0' at the end of the projection year.

5. International out-migration is calculated by applying age and sex specific rates to the population and subtracting the result.

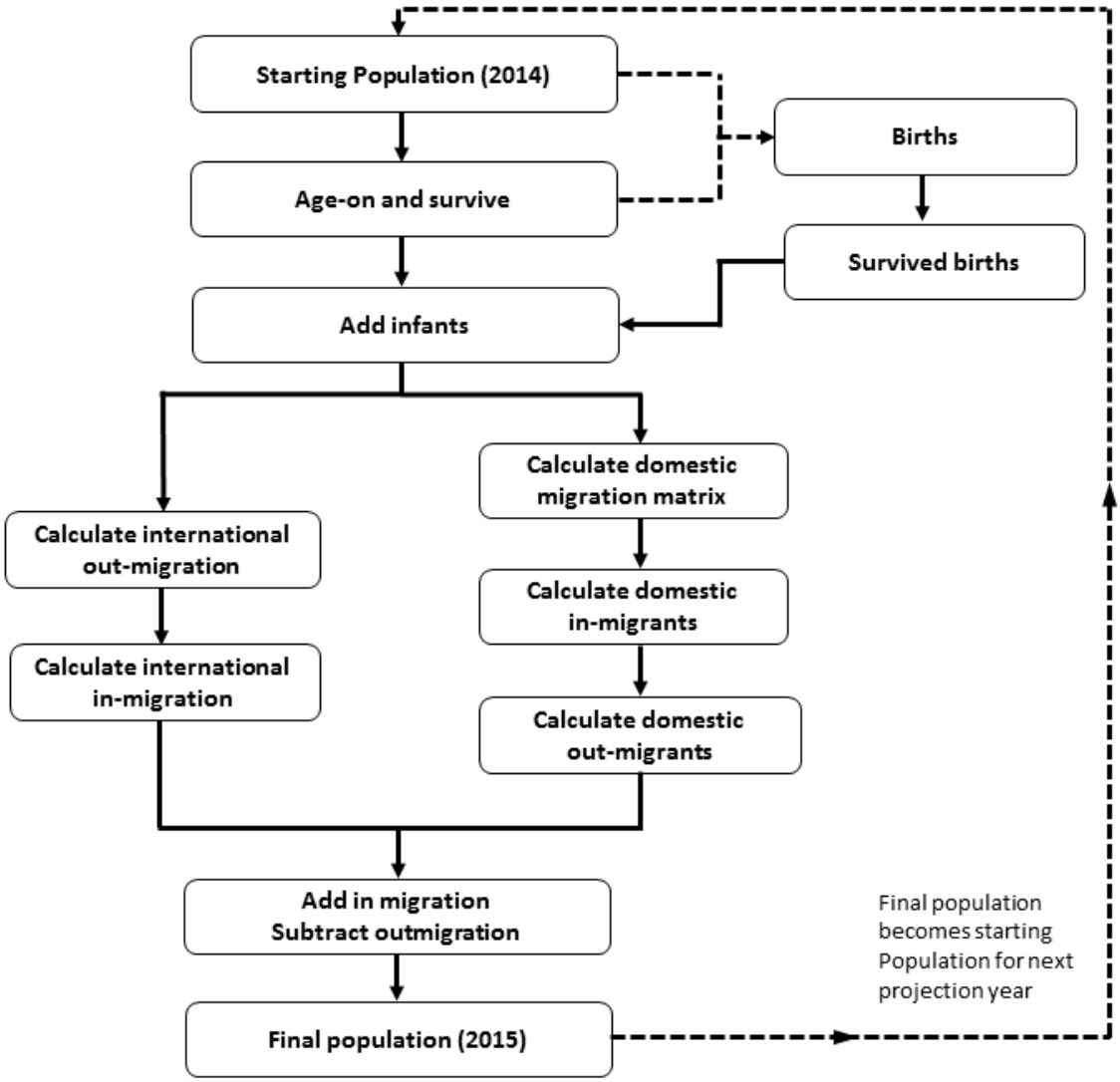
6. Numbers of in-migrants from overseas are projected from the historic record of international migrants and a constant age and sex distribution of the totals.

7. A domestic migration matrix is calculated by applying age and sex specific out-migration probabilities to the population. The matrix includes flows (by age and sex) between all local authorities in England as well as Northern Ireland, Scotland and Wales. Local authority-level in and out migration are calculated by summing the inflows and outflows for each authority.

8. The final population for the projection year is fed back into step 1 as the initial population for the next projection year.

The model outputs estimated and projected population by single year of age and sex from 2011 to 2050. Additional reporting outputs are also produced, including: births, deaths, total fertility rates, life expectancy at birth, and gross migration flows.

Figure 1: Flow Chart of the Projection cycle



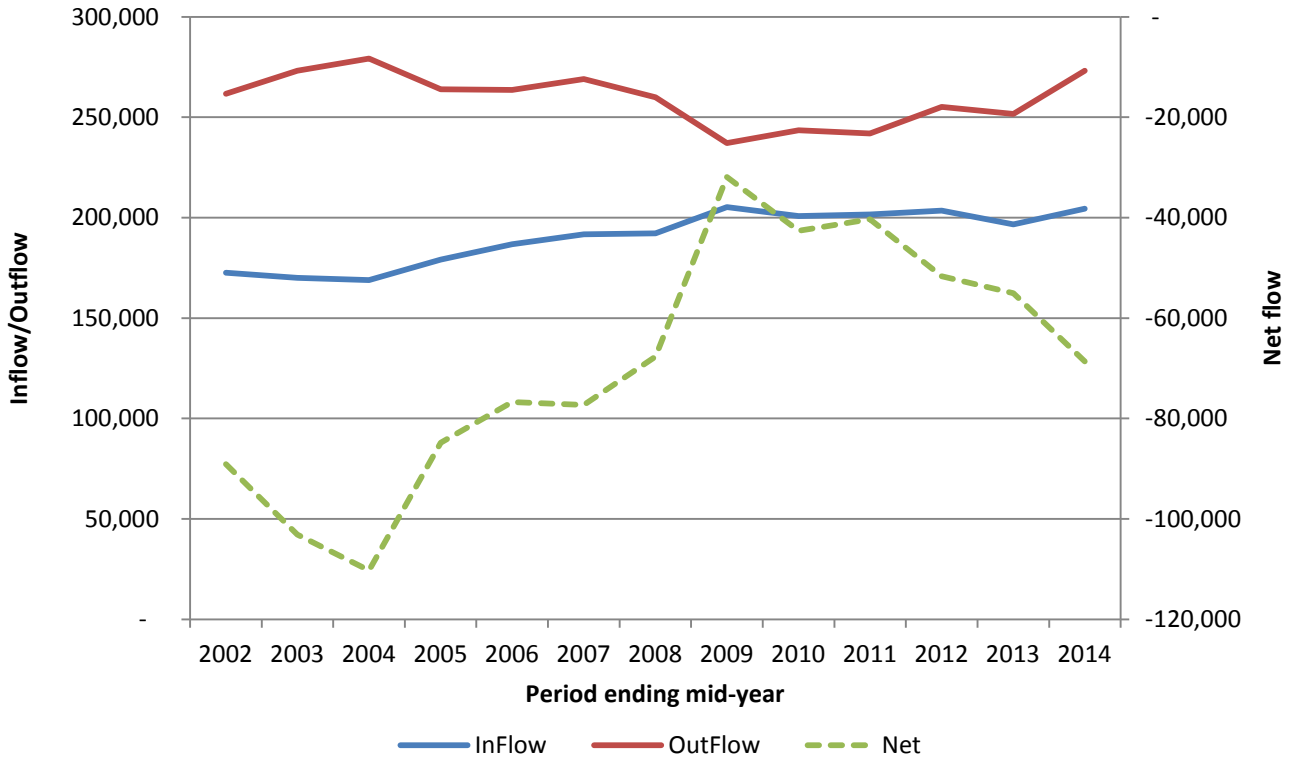
GLA Demography, 2016

Projection variants

Two different projection scenarios were modelled, primarily to reflect uncertainty in future migration patterns. These are labelled as the short- and long-term migration scenarios, respectively. Migration flows are the most variable and difficult to project component of population change and the very large scale of flows into and out of London makes the projections especially sensitive to the assumptions used.

The financial crisis of 2008 appeared to trigger a significant change in domestic migration patterns between London and its neighbouring regions – in terms of both the size and age characteristics of those flows. Figure 2 below shows domestic flows to and from London for the period 2002 – 2014.

Figure 2: Domestic migration flows 2002-2014, London



ONS Internal Migration backseries

There has been much discussion and speculation about how migration patterns may change as the economy recovers from the immediate effects of the crisis. Some of the change in patterns is likely to be transitory (linked to problems in the housing market, access to mortgages, etc) while some changes may be indicative of a structural shift. This poses a difficulty when projecting forward 25+ years. If one considers recent patterns to be a temporary aberration linked to the crisis, then to project forward using only recent trends is likely to give a distorted view of the long-term future, even though it may yield the best results in the near-term.

This issue is addressed in this round of projections by producing two variants: one based on short-term migration trends and the other on longer-term migration trends.

The short-term variant assumes that recent migration patterns will persist for the duration of the projection period. In this sense it is similar to ONS's 2014-based subnational population projection. While projections based on this approach are suitable for use in the near-term, the GLA has argued that a projection based only on recent patterns, especially those which are so heavily influenced by a single event are not a suitable basis for long-term planning. When projecting further ahead it is generally better to base assumptions on longer historical trends, preferably spanning a full, or multiple, economic cycles. To this end, the GLA has produced a variant based on a longer period of past migration data. In addition to being more conceptually sound as a basis for long-term projection, using a long-term trend has the advantage of yielding more stable projections between successive projection rounds when compared to those produced using short-term trends only, as each additional year of data has a smaller proportional impact on the overall trend.

The bases for the trends used in short- and long-term scenarios are as follows:

- The short-term migration scenario bases the migration patterns on estimates for the **five-year period** mid-2010 to mid-2014.

- The long-term migration scenario bases the migration patterns on estimates for the **12-year period** mid-2003 to mid-2014.

The projections are otherwise the same in terms of methodologies and assumptions regarding fertility and mortality.

Internal Migration series

Changes in the availability of domestic migration data mean that the back-series used in the 2015 round of projections has been revised. Specifically, in January 2016 ONS released the Internal Migration series which makes available local authority to local authority flows by single-year-of-age and sex for the period mid-2002 to mid-2014.

Previous rounds of GLA projections modelled the interactions between London Boroughs and between three areas outside London (South East region, East region, Rest of UK). The rates used were based on census estimates. For the 2015 round the model takes advantage of the Internal Migration series to project flows based on 329 areas (all LAs in England plus Northern Ireland, Scotland and Wales) by sya and sex.

Base Population

A series of population estimates prior to the 2011 starting population is required by the model in order to generate the rates and probabilities used to project forwards. When the 2011 mid-year estimate was first released, no consistent back-series of estimates was available. Ahead of the 2012 round projections, the GLA produced a set of estimates consistent with the 2001 and 2011 mid-year estimates.

In summary, this series of estimates was produced as follows:

1) Birth, death and gross migration flow totals were taken from ONS estimates. International inflow estimates from mid-2005 onwards (those based on the Migration Statistics Improvement Programme methodology) were used unchanged - prior estimates were adjusted to give a consistent set of population totals between 2001 and 2011.

2) A natural change model (no migration component) was used to roll forward the 2001 mid-year estimates to create a set of estimates for 2002 to 2011.

3) The differences, by age and sex, between the natural change model results for 2011 and the 2011 mid-year estimate were calculated to give an estimate of the net impact of migration.

4) A proportion of this net impact of migration estimate was apportioned to each year of the natural change model estimate, such that the population totals were consistent with the totals arrived at in the first step.

The GLA initially intended this series to serve only as a stop-gap measure until the arrival of the ONS's own back-series the following year. However, once this was received, the GLA felt that it was unsuitable for use

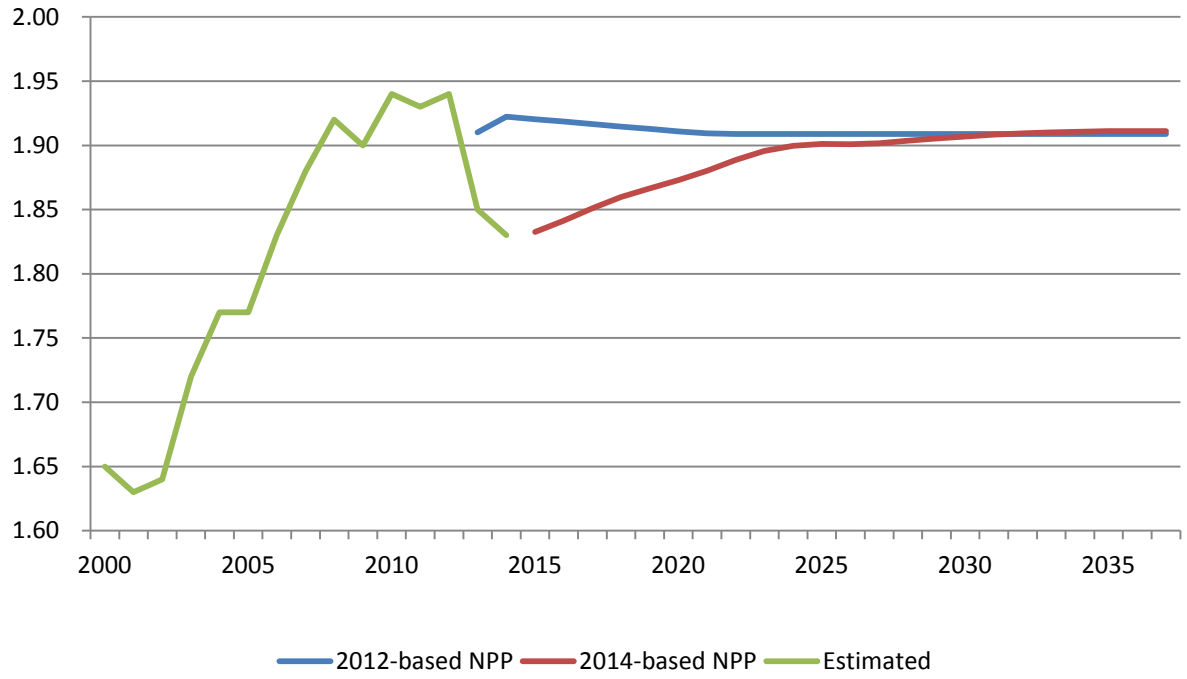
in the projection model due to issues with how ONS had accounted for differences between the original and Census-based estimates. As such, the GLA is continuing to use the series it produced in 2012 and will consider refining this series in future.

Births

For the 2015 round projections an initial set of age-specific fertility rates (ASFR) are estimated using data from the ONS 2012 sub-national population projection (SNPP) and actual births data as reported in the Mid-Year Estimate for 2014. The projected 2013 ASFR from the SNPP is scaled to be consistent with total births for 2014 taken from the MYE. Assumed fertility rates beyond 2014 follow age-specific fertility trends taken from the ONS 2012-based National Population Projections (NPP).

The 2012-based NPP principal ASFR projection is favoured over the 2014-based NPP principal ASFR projection as it provides a more stable projection of future fertility. Figure 2 shows Total Fertility Rate (TFR) – the result of summing the ASFR rates – for both the 2012-NPP and 2014-NPP principal projections as well as estimated TFR for the period 2002 to 2014.

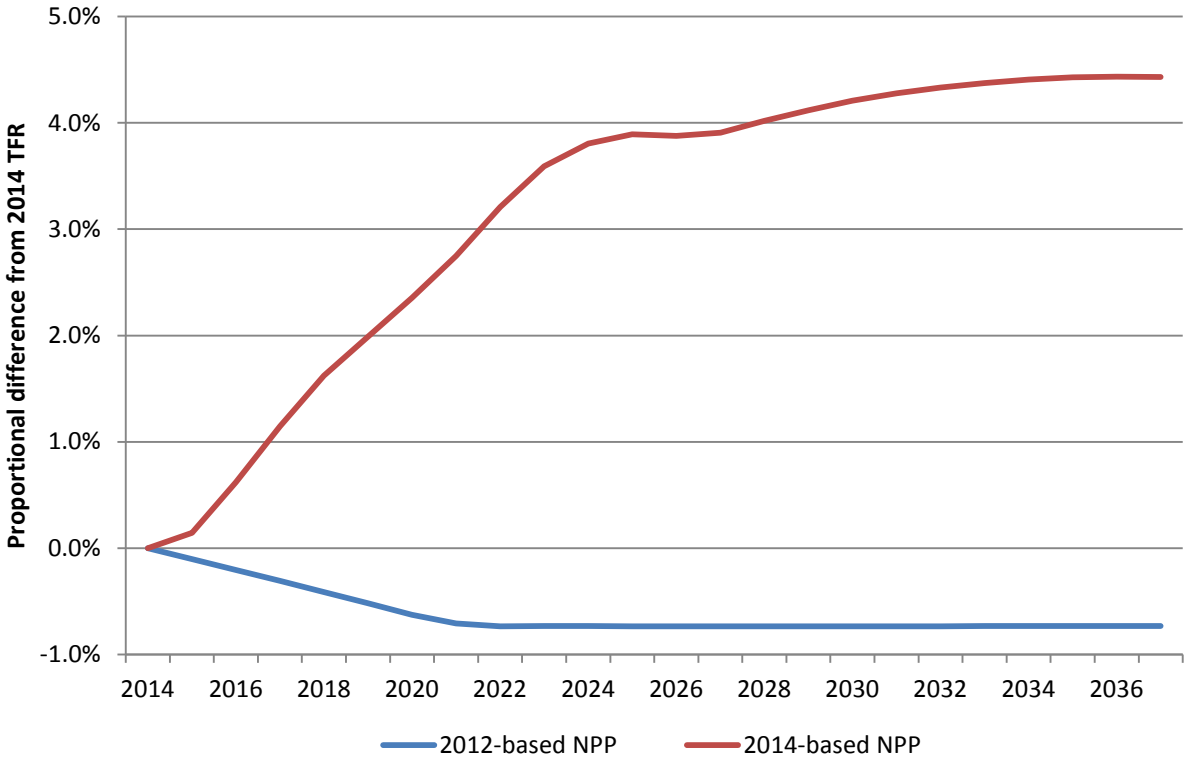
Figure 3: Total Fertility Rate for England & Wales, observed and projected



Birth Summary Tables, ONS (2013), 2012-NPP, 2014-NPP

Fertility fell significantly between 2012 (TFR 1.94) and 2014 (TFR 1.83) accounting for the different starting points in the two TRF trends in Figure 3. The 2012-NPP TRF trend show a relatively static trajectory with values between 1.91 and 1.92. The 2014-NPP trajectory projects an initial steep rise in TRF from 1.83 to 1.90 over the first decade after which the rates stabilise.

Figure 4: Proportional change in TFR relative to 2014, England & Wales



Source: ONS 2012- based NPP, 2014-based NPP

Figure 4 shows the proportional change in TFR relative to the 2014 base line. It demonstrates the clear differences in the two trajectories. The GLA believe that the more stable 2012 trajectory is a more likely scenario and therefore the ASFR trends from the 2012-NPP are used rather than the more up-to-date 2014-NPP rates and trends.

Detailed Methodology

1) Projected ASFRs for 2013 (taken from the 2012 SNPP) are modified to include ages 45-49 and are applied to estimates of the female population to produce an estimate the number of births in 2014.

2) The estimate is compared to the actual births data taken from the ONS mid-year estimates, and the ASFRs are scaled so that they yield the correct number of total births.

3) The scaled rates are then modified for each projection year by applying the proportional changes in the England ASFR from the 2012-based NPP Principal assumption relative to the base year (2014).

4) As births occur throughout the year, projected births are calculated by applying ASFRs to an average of the starting and aged-on-and-survived populations.

5) Projected births are assigned a sex based on the ratio of 105 males to 100 females.

Deaths

Deaths are calculated by applying Age-Specific Mortality Rates (ASMR) to the population. ASMRs for 2014-15 are based on linear extrapolations of the previous five years of mortality rate estimates. Assumed mortality rates beyond 2015 follow-age specific mortality trends taken from the 2014-based NPP.

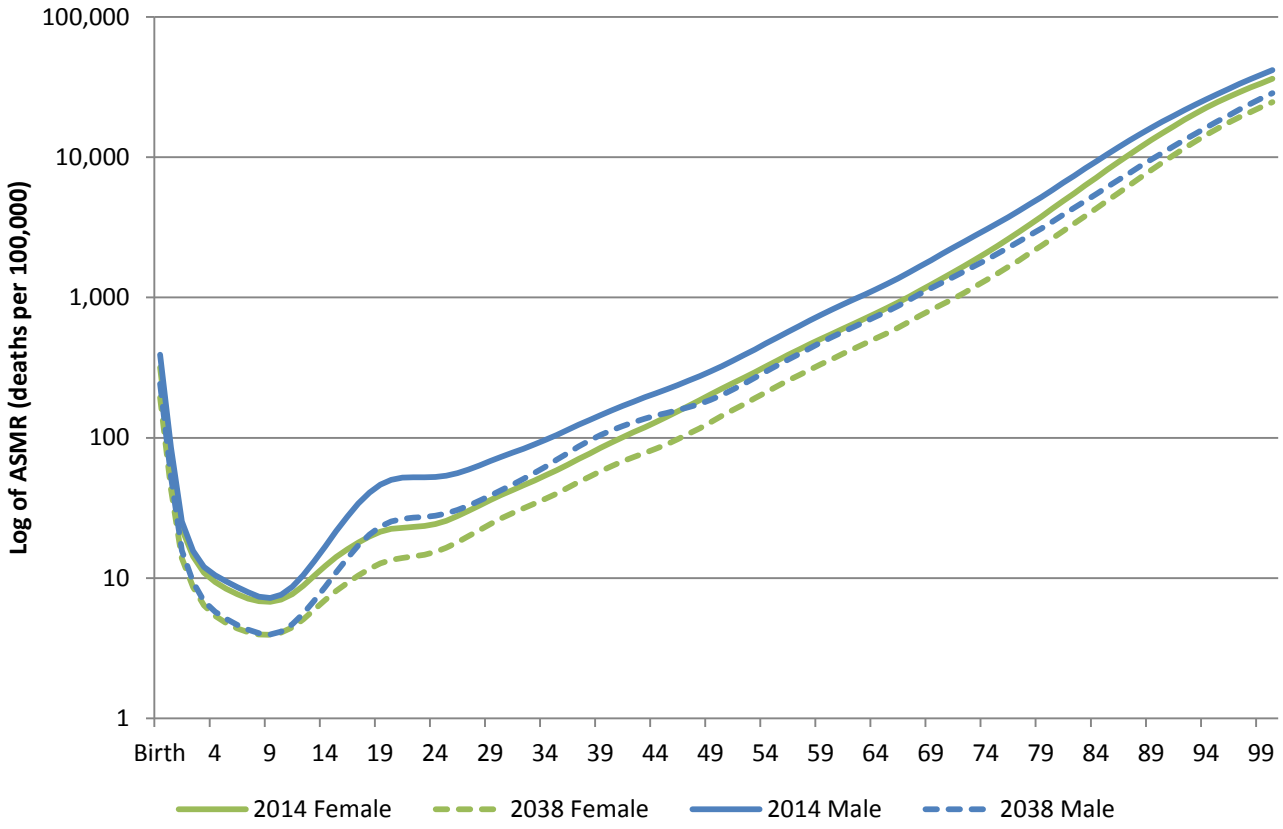
Detailed methodology

1) Base ASMRs are calculated using population estimates and data from ONS on deaths by age and sex for the period mid-2010 to mid-2014.

2) A linear trend of the mortality rates is extrapolated to give a projected ASMR for 2014-15.

3) For subsequent projection years, the mortality rates are modified by the proportional change in the ASMRs from the 2014-based NPP Principal assumption.

Figure 5: Age Specific Mortality Rates, England and Wales, 2014 & 2038



Source: ONS 2014 -based NPP

International Migration

International out-migration is calculated by applying age-specific out-migration probabilities to the population. These probabilities are the average of previous years' out-migration rate estimates. The short-term model variant uses five years of data (mid-2010 to mid-2014) while the long-term variant uses 12 years (mid-2003 to mid-2014).

International in-migration is calculated by taking an average of inflows by age and sex in previous years and holding that inflow constant for the duration of the projection.

Detailed methodology

1) Base out-migration probabilities are calculated using international outmigration and population estimates from ONS Mid-Year Estimates for the defined period (5 or 12 years).

2) An average of the rates for the defined period is taken.

3) For the projection years the age and sex specific rates are applied to the population.

4) Total inflows from overseas by age and sex are taken from the ONS Mid-Year Estimates for the defined period (5 or 12 years).

5) An average of the inflow is taken.

6) For the projection years the resulting population is added to the projection.

Domestic Migration

Domestic migration is calculated using a multi-region model to project the flows between 323 areas:

- 33 London boroughs
- 293 local authorities in England
- Northern Ireland, Scotland and Wales

Domestic migration probabilities by age and sex are calculated from ONS Internal migration data and mid-year population estimates. The short-term model variant uses five years of data (mid-2010 to mid-2014) while the long-term variant uses 12 years (mid-2003 to mid-2014).

Detailed methodology

1) Base age and sex specific out-migration probabilities are calculated for each area pairing. These probabilities use domestic out-migration estimates from the Internal Migration series and population estimates from ONS Mid-Year Estimates for the defined period (5 or 12 years).

   For each year this creates a 4-dimensional domestic migration matrix comprising 18,987,878 rates – 323 areas x 323 areas x 91 ages x 2 sexes.

2) An average of each the rates for the defined period is taken (5 or 12 years).

3) For the projection years, the age and sex specific rates are applied to the population to calculate flows between each pair of areas.

4) For each area age and gender domestic in-migration and domestic out-migration figures are calculated by summing from the individual area to area flows.

5) In-migration totals are added to the population and out-migration totals are subtracted.

Households

The model developed for the 2015 round of projections produces implied households as a standard output. Households are arrived at by applying the methodology from the DCLG's 2012-based household projections[1].

Outputs

In addition to the projected population by single year of age (sya) and sex, the model outputs include:

- Total Births
- Births by mother's age
- ASFRs & TFRs
- Total deaths (by sya/sex)
- Life Expectancy
- Domestic & Internal Gross and Net flows (by sya/sex)
- Borough and regional aggregations

For the initial release of the 2015 round projection, the GLA intend to publish projections and associated data for local authorities in London only.

[1] The DCLG 2012 household projection methodology document can be viewed here: https://www.gov.uk/government/statistics/2012-based-household-projections-methodology

Appendix A:

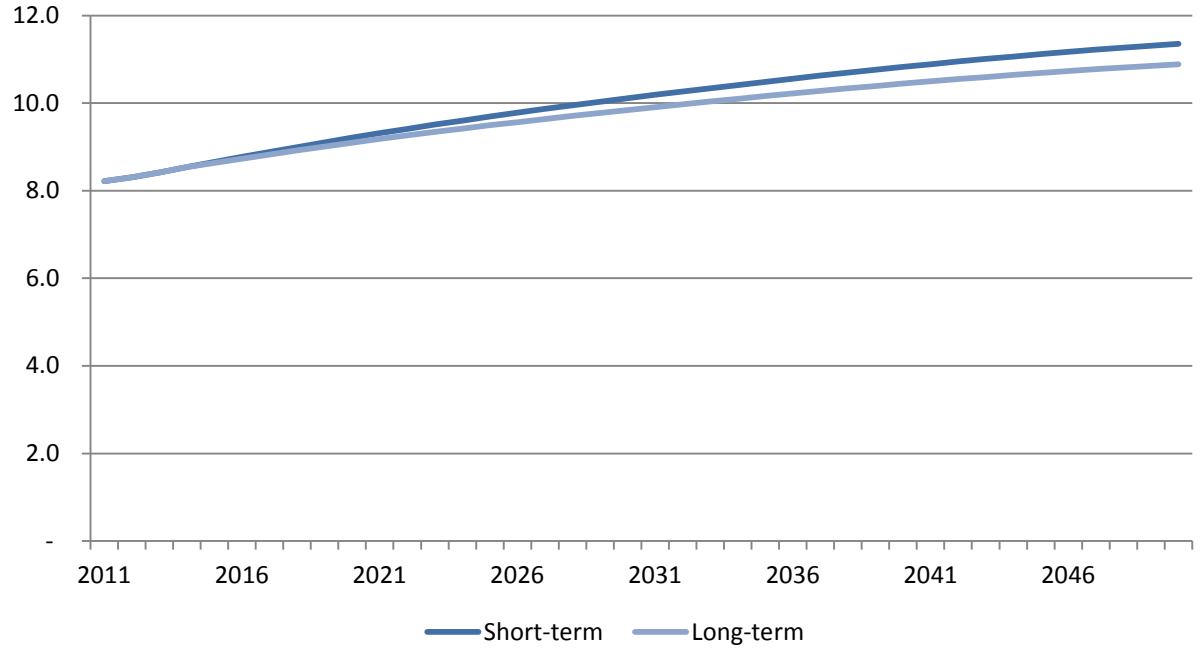
Impact of migration period selection

A key driver in the development of the expanded cohort component model has been the desire to better understand the impact of changing the backseries used in calculating domestic migration probabilities. In addition, the ability to project how different assumptions impact populations in those areas which interact with London provides a potentially useful strategic planning tool.

Figure 5 shows the projected population of London for two model variants: 5- year migration and 12-year migration. In the final projection year the 5-year variant projects an additional 467,200 (4.3 per cent) in London over the population projected by the 12-year variant. This is the case because the data in the 5-year variant covers the recession period in which out-migration from London has been supressed causing net migration to increase. Over the longer 12-year period the incorporation of the pre-recession data evens out this effect.

The implied household growth from the two variant populations also differs. The 5-variant projects 5.16 million households by 2050, an annualised growth over the 35-year period 2015-2050 of 47,100 households. Under the 12-year projection the 2050 figure is 4.89 million, 275,500 households less. The annualised growth to 2050 is 39,600.

Figure 6: Projected population 2011-2050, London



Source: GLA 2015 round population projections

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