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statistics for wales

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Sub-national Projections for Wales

Technical report on the local authority and National Parks population and household projections for Wales

Contents

Background and introduction

The main aim of the population projections is to provide an estimate of the size of the future population, and national population projections are produced by ONS on behalf of the National Statistician and the Registrars General of Scotland and Northern Ireland. The assumptions on which the projections are based are agreed with the devolved administrations. A new set of projections is currently produced every two years by ONS, based on a full-scale review of the trends affecting the underlying assumptions about fertility, mortality, and migration. The projections for the UK and its constituent countries are based on the mid-year estimates of the population. Details of the background to the national population projections and the methodology used are here (together with details of the subnational population projections for England and the cross border migration rates):

The Welsh Government produces population projections and household projections for two standard classifications of sub-national geographies: local authorities and national parks. The projections are usually produced for the following 25 years.

Sub-national projections for England are produced by the Office for National Statistics (ONS), for Scotland by the National Records of Scotland (NRS), and for Northern Ireland by the Northern Ireland Statistics and Research Agency (NISRA).

The Welsh Government consultation on *Statistical Outputs on Population and Household Estimates and Projections* took place in the first half of 2016. Most respondents thought that sub-national population projections and household projections should be produced once every three years, and this is the current plan.

Household projections provide estimates of the future numbers of households and of the numbers of people who live in them, and are based on population projections and a range of assumptions about household composition and characteristics. There are three national parks in Wales, which overlap several local authorities. This technical report describes in detail the methodology for calculating the population projections for local authorities, and how this methodology is adapted to produce household projections and projections for national parks.

Local authority population projections

The latest local authority population projections for Wales were 2014-based and the latest ones for National Parks in Wales were also 2014-based. These projections were developed by statisticians within the Knowledge and Analytical Services department of the Welsh Government, under the independent responsibility of the Chief Statistician for the Welsh Government and in line with the Code of Practice for Official Statistics. This technical report describes how these population projections were produced, and the detailed methodology used to derive the assumptions for fertility, mortality, and migration.

Population projections provide estimates of the size of the future population, and are based on assumptions about births, deaths, and migration. The assumptions are based on past trends. The

local authority population projections indicate the population size if the trend-based assumptions continue to hold.

There is a high level of interest in population and migration data for Wales, and a strong demand for projections at the sub-national level. Those who plan for the future, to deliver services and to help frame sustainable policies, need to consider the size of the population by age and sex. The assumptions on which the projections are based are generally derived from past trends. The projections do not make allowances for the effects of local or central government policies or for changing economic circumstances on future population levels, distribution and change. They indicate what is expected to happen if the trends on which they are based continue. However the projections are useful as a basis for planning services and to estimate future need. Population projections can identify trends that shape the context for future policy development.

Every ten years the Office for National Statistics (ONS) carries out a comprehensive count of the population known as the Census. The most recent census was taken on 27 March 2011. The first results of the 2011 Census were published in July 2012. These were followed, in September 2012, by population estimates for mid-2011 which were the first mid-year estimates to take into account the results of the 2011 Census.

In March 2013 ONS published revised ‘components for change’ for local authority population estimates for the years 2002 to 2010 which had been revised to take into account the results of the 2011 Census. These included revised estimates of migration both international and within the UK for these years. The revised estimates of migration were used to base assumptions for the 2011-based and 2014-based local authority population projections and the 2013-based and 2014-based national park projections.

Annexe 2 provides a comparison of the most recent set of local authority projections with the mid-year estimates produced by ONS.

1. Difference between the National Projections and the local authority projections

The population projections based on the mid-year population estimates for 2011 were the first set of local authority population projections for Wales to take into account the results of the 2011 Census. They were published for the years 2011 to 2036 for each local authority in Wales, and by sex and single year of age. The most recent local authority population projections for Wales were based on the mid-year population estimates for 2014 and cover the 25-year period from 2014 to 2039.

The results by local authority do not sum to the national population projections produced by ONS. This has been true since the production of 2006-based local authority projections. Guidance on using the two sets of projections is provided in the Guidance Leaflet.

The key aim of this work is to produce robust local authority population projections for Wales, which reflect local trends in recent years. For the national projections the aim is to produce robust population projections for Wales which reflect national trends in recent years.

The national projections and the local authority projections are different for the following two (main) reasons.

(a) assumptions

The methodology used to produce assumptions in the local authority projections is different from that used in the national projections, including the use of slightly different data sources. For example, ten years of within-UK migration trends were used to determine migration assumptions in the national projections, and five years of migration data were used in the principal local authority projections.

Also, although one set of assumptions may fit well for a national trend, using similar assumptions may not always produce feasible results for all 22 local authority areas because of the different nature and trends between local authorities.

(b) geographical level for which the assumptions are based and applied

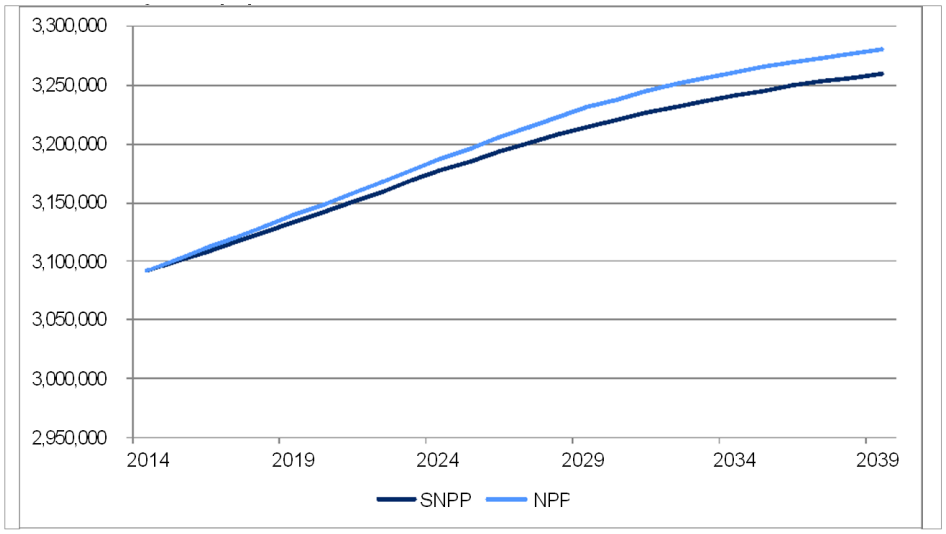
The geographical level for which the assumptions are specified and applied is also important. For example, it is not appropriate to sum local rates (for example, fertility) to derive a national rate, and therefore a model operating at different geographic levels (but using rates) will produce different results for the differing geographic levels.

National Population projections and the sum of the 22 local authority projections

It is possible to quantify the differences observed as a result of using different assumptions by comparing the national population projections with a Wales level projection. The sum of 2014-based local authority population projections can be compared to the 2014 National Population Projections (NPPs) produced by the ONS.

Figure 1 shows the sum of the local authorities from the Sub-National Population Projections (SNPPs) with the ONS NPPs.

Figure 1: Projected population for Wales, 2014 to 2039



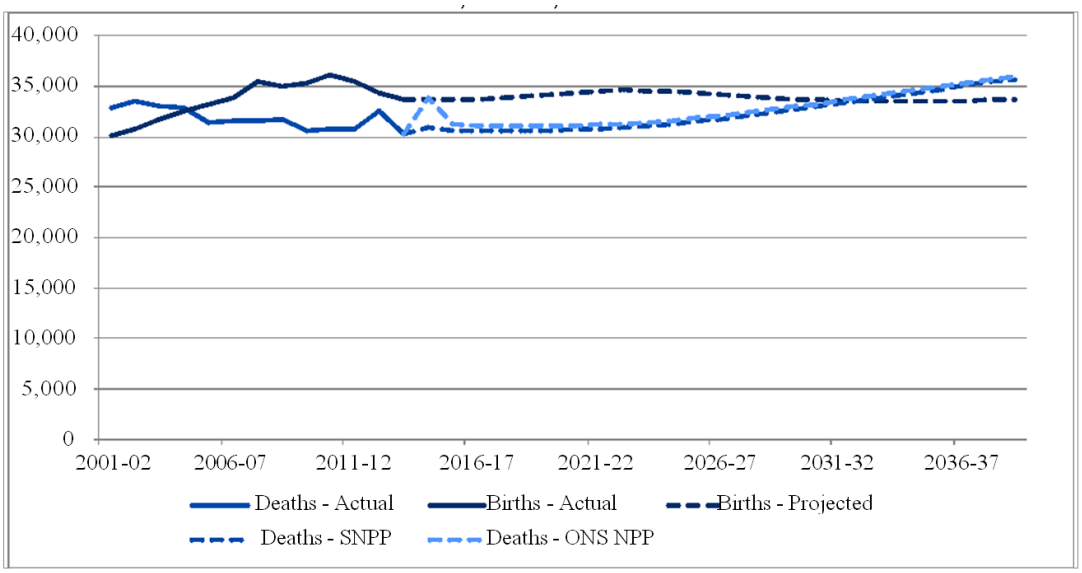
The NPPs produced by the ONS are slightly higher than the sum of the Local Authority projections by 20,600 in 2039, which is 0.6 per cent. There are a number of reasons why there are differences between the two projections. Because of the different base year of the projections, there is a difference between the aggregated local authority projection and the base data of the national population projection for 2014.

Further work would need to be undertaken to fully explain the reasons behind these differences, although a comparison of births and deaths components of each set allows some analysis (see figure 2). The methodology for the local authority population projections produces projected numbers of births and deaths by local authority for Wales. The projected numbers of births and deaths are based on average fertility and mortality rates for the five years leading up to mid-2014 and assumed trends from the National Population Projection (NPP) for Wales. Projected natural change is the difference between the two; that is, natural change is the number of births minus the number of deaths.

The numbers of births in the initial year of the national projections is lower than the 2014-based local authority projections and increases gradually up to the start of the 2020s. This could be explained by the fact that the numbers of births fell in the years after 2010 , in contrast to the increases seen in the decade leading up to the projections,

Trends in mortality are similar, although the number of deaths according to the national population projections, based on more recent data, begin at a slightly higher level and that gap remains for the first few years of the projection period.

Figure 2: Trends in births and deaths, Wales, 2001-02 to 2038-39



The assumed levels of internal and international migration are based on average migration numbers for the five years leading up to mid-2014, and these are held constant for the projection period.

The 2011-based local authority projections also assumed a higher level of net migration (+8,000) than the national population projections (+5,000 to 6,000 for most years); and the same assumption was made for the 2014-based projections.

Since migration levels can fluctuate from year to year, the projected levels of migration are also uncertain and are dependant on a range of other factors.

Approach to producing local authority projections

Local authority population projections for Wales have been developed in close collaboration with local authorities and key users in Wales since 2008. From 2012 onwards this has been through the Wales Sub-national Projections working group (WASP). The WASP group is a subgroup of the Welsh Statistical Liaison Committee and meets regularly as a forum for technical discussions on the methodology, assumptions, and base data used for the local authority population and household projections for Wales. Members of WASP include local authority representatives with knowledge of or experience of demographic data and population projections.

The approach used to develop the 2014-based local authority projections is similar to that used in previous Welsh Government Local Authority Projections (2006-based, 2008-based, and 2011-based projections). This approach uses local data and local trends, but does not force the local authority projections to sum to the national population projections published by ONS.

In addition, a Projections Stakeholder Group was established during 2013 to discuss and advise on wider issues relating to population and household projections in Wales, including user needs, formats of outputs, communication plans, and advice on how projections can be used within housing, planning and other functions.

Regular updates have also been provided at full meetings of the WSLC. There is further information on the WSLC (including membership) on the Welsh Government website.

A number of projections are made available in the published material. The main (or principal) projection is based on recent past trends in births, deaths, and migration. This technical report describes in detail how these principal projections have been derived.

In order to illustrate the uncertainty associated with projections, (usually) four variant projections are published for each local authority alongside the main (or principal) population projection. These variant projections are illustrative to show how possible variations in the fertility, mortality, and migration assumptions affect the projections and how the size of this effect increases the further into the projection period the results are taken. The four variant projections usually published are:

- A *higher population variant* which is based on assumptions of higher fertility rates and lower mortality rates.
- A *lower population variant* which is based on assumptions of lower fertility rates and higher mortality rates.
- A variant in which the migration assumption is based on the *average migration* over a longer, 10-year period.
- A *zero migration* (natural change only) projection to illustrate the projected population of each local authority if there were no future inward or outward migration.

Limitations of population projections

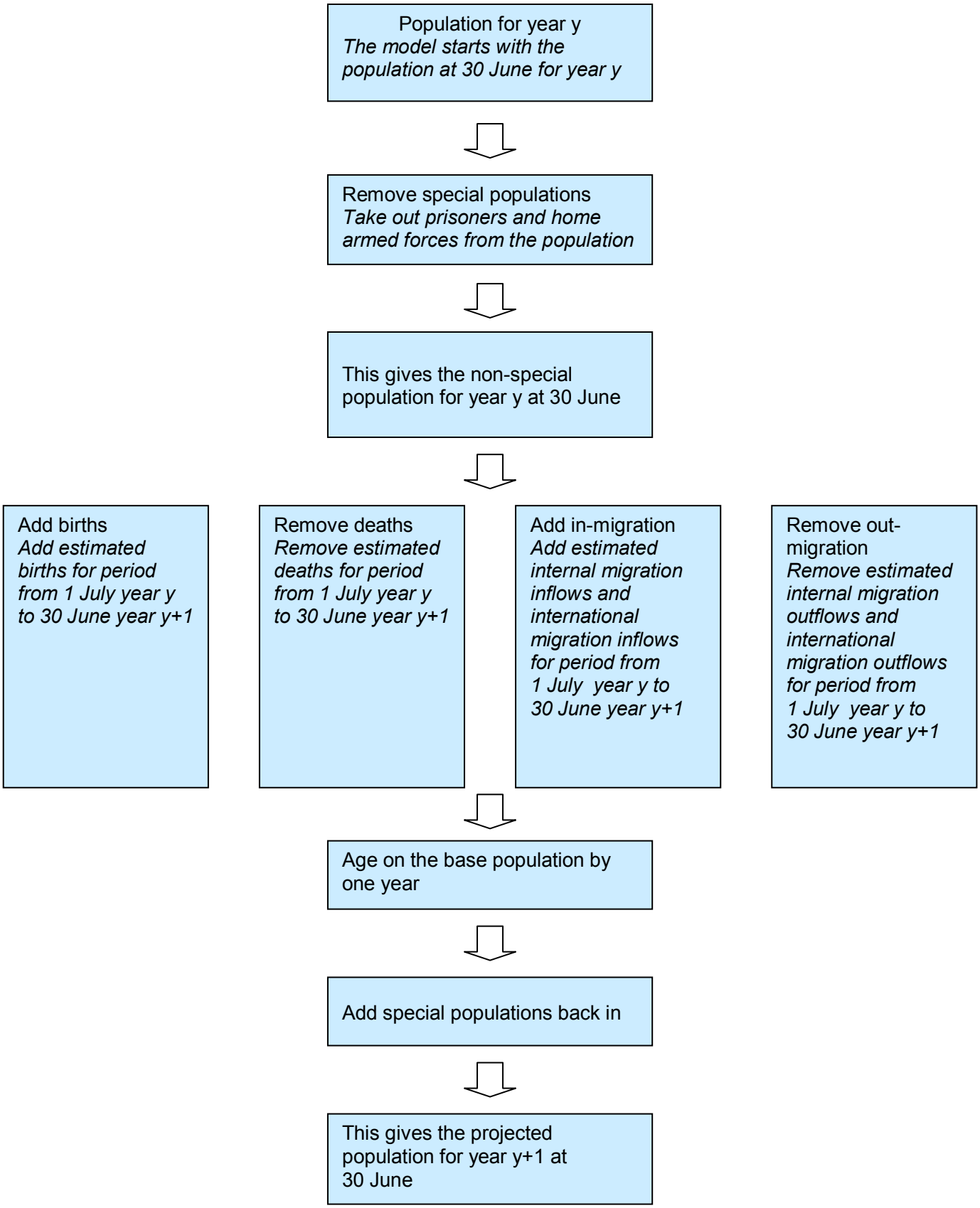
Population projections have limitations. These local authority population projections indicate what is expected to happen if the trend-based assumptions continue. They are not policy-based forecasts and they do not make allowances for the effects of local or central government policies or changing economic circumstances on future population levels and distribution.

As the process of demographic change is cumulative, projections become increasingly uncertain the further they are carried forward. Demographic change affects some populations more rapidly and more seriously than others. Due to the size of migration flows, for some local authorities, migration assumptions are more critical than fertility and mortality assumptions. Therefore, migration assumptions can have a significant effect on certain areas in the long-term.

Local authority population projections indicate the likely population size and profile, if existing trends continue. This may lead to new policies being introduced, which may result in the original projections not being realised. This means that the population projections will have met one of their main functions: to illustrate the consequences of recent and current demographic trends, and allow policy makers and service delivery planners an opportunity to allow for this this.

2. The population model

This flow diagram gives a brief overview of the local authority population projections model:



The population model in more detail

Notation:

P^t total population including special populations

P total population without special populations

S special populations

x sex

y year

Note that this symbol refers to populations at the end of the mid-year, 30 June in year y, and refers to births, deaths and migrant numbers during the twelve months beginning 1 July 1 in year y.

a age

a takes the values *nb, 0, 1, 2,…..89, 90+*.

Note that *nb* refers to those who will be born during the year beginning 1 July.

B births

D deaths

IMI internal migration inflows

IntMI international migration inflows

IMO internal migration outflows

IntMO international migration outflows

The model below sets out how to project forward the population at 30 June year y, $P^t_{a,x,y,}$ in order to obtain the population at 30 June in the following year $P^t_{a,x,y+1.}$

For each group, the non-special population at the start of the current year y, $P_{a,x,y}$,is first computed:

$P_{a,x,y} = P^t_{a,x,y} – S_{a,x,y}$

where $P^t_{a,x,y}$ is the total population including special populations and S is the sum of the special populations.

Births, deaths and migrants for year y are calculated and then used to compute the population forecast $P_{a,x,y+1}$ for sex x, age a, for 30 June year y+1, as follows:

For age a=0:
$P_{0,x,y+1} = Bx_{,y} - D_{nb,x,y} + IMI_{nb,x,y} + IntMI_{nb,x,y} - IMO_{nb,g,y} - IntMO_{nb,g,y}$

For age a=1 to 89:
$P_{a,x,y+1} = P_{a-1,x,y} - D_{a-1,x,y} + IMI_{a-1,x,y} + IntMI_{a-1,x,y} - IMO_{a-1,x,y} - IntMO_{a-1,x,y}$

For age 90+:
$P_{90+,x,y+1} = P_{89,x,y} - D_{89,x,y} + IMI_{89,x,y} + IntMI_{89,x,y} - IMO_{89,x,y} - IntMO_{89,x,y} + P_{90+,x,y} - D_{90+,x,y} + IMI_{90+,x,y} + IntMI_{90+,x,y} - IMO_{90+,x,y} - IntMO_{90+,x,y}$

Once these population estimates by single year of age have been computed, the base population is aged on a year and the special populations are added back in to give the population estimates by single year of age as at 30 June for the year y+1. The total population including special populations for 30 June year y+1, $P^t_{a,x,y+1}$,can then be calculated.

Information on the methodology used to calculate the separate births, deaths and migration components can be found in the sections that follow.

Constraining

The local authority population projections are not constrained to the National Population Projections for Wales. Guidance on using the two sets of projections is provided in this Guidance leaflet

3. Fertility assumptions

In order to project the number of births in each local authority during each year of the projection period, fertility assumptions were produced for each local authority. This section describes how these fertility assumptions were formed.

Age Specific Fertility Rates (ASFRs) were used as the basis for the fertility assumptions. ASFRs are a measure of fertility specific to the age of the mother, and are useful for comparing the reproductive behaviour of women at different ages. ASFRs were calculated by dividing the number of live births to females aged X by the total number of females aged X and multiplying by 1,000.

The data source was the Vital Statistics Registration Online System which is run by the ONS.

The section below summarises the key steps that were taken to calculate the fertility assumptions. More detail is given in the sections that follow.

Key Decisions

On what time period were the fertility assumptions based?
The software used to calculate the projections is designed to use data which is on a mid-year to mid-year basis. For consistency all the data used to form the fertility assumptions were on a mid-year to mid-year basis (i.e. 1 July to 30 June).

To which female population group were fertility rates applied?
The female base population used for the denominator of the fertility rates was an estimate of the female population aged a during the mid-year to mid-year period.

How was data volatility dealt with?
Assumed fertility rates were derived from a 5-year average ASFR (adjusted to 2013-2014 local authority birth levels) in order to reduce data volatility.

How were future changes in fertility rates accounted for?
Fertility differentials over time were used to take into account projected changes in fertility over time. Fertility differentials were calculated from fertility data from the latest published Wales National Population Projections (2013-based). They are a measure of the projected year on year change in fertility data from the national projection for Wales.

How were projected births distributed to males and females?
The ‘boys per 1,000 girls ratio’ was set to 1,050 boys per 1,000 girls for each local authority.

Calculating the initial ASFRs

ASFRs were calculated for females aged 15 to 49 by single year of age for each local authority in Wales. ASFRs were calculated by dividing the number of live births to females aged X by the total number of females aged X and multiplying by 1,000. The ASFRs were based on mid-year to mid-year data for the most recent five years.

Note that births for mothers aged under 15 and over 49 were included in the calculations for 15 and 49 year olds respectively.

A population denominator is needed to calculate the five year average ASFRs. For the 2014-based projections the approach followed that was used in the previous (2006-based, 2008-based, and 2011-based) projections as follows:

Population base for ASFRs:

The estimated average population aged *a* during the mid-year period:

$$\frac{\left(MYE_{[a,y]} + MYE_{[a-1,y]}\right)}{2}$$

where y=year, a=age, and MYE= mid year population estimate

For example the estimated population of women aged 30 during the year mid-y to mid-y+1 would be as follows:

$$\frac{\left(MYE_{[30,y]} + MYE_{[29,y]}\right)}{2}$$

This population base was chosen because it is the same population base that Popgroup uses to calculate the predicted number of births. This approach ensured consistency.

More information on how Popgroup calculates the predicted number of births is given in section 3f).

ASFR Calculation

The historic ASFRs were initially calculated for females as:

$$ASFR_{[a,y]} = \left(\frac{\left(B_{[a,y]}\right)}{\left(\frac{MYE_{[a,y]} + MYE_{[a-1,y]}}{2} \right)} \right) * 1000$$

For: a = age
y = year
B = Number of births
MYE = mid-year population estimate

Note that the mid year estimates of the population refer to the population at 30 June of year y. The births figure refers to the total births from 1 July of year y to 30 June year y+1 to women aged *a* at birth of child.

For example to calculate the ASFR for women aged 30 for the year y - y+1:

Population base would be as previously shown:

$$\frac{\left(MYE_{[30,y]} + MYE_{[29,y]}\right)}{2}$$

ASFR would be as follows:

$$ASFR_{[30,y-y+1]} = \left(\frac{\left(B_{[30,y-y+1]}\right)}{\left(\frac{MYE_{[30,y-y+1]} + MYE_{[29,y-y+1]}}{2} \right)} \right) * 1000$$

Where $\left(B_{[30,Y-Y+1]}\right)$ refers to all live births between 1 July y to 30 June y+1 to women aged 30 at birth of child.

How was data volatility dealt with?

In producing ASFR assumptions the aim was to:

a) reduce the number of zeroes at the single year of age level, so that zeroes are only found when there is a trend for no births to be seen to mothers of that age (and therefore the ASFR is zero) and this is not just a one year anomaly.

b) reduce the volatility of data at the single year of age level. For example, if very few births are normally seen to women aged 42, but in one year 3 women aged 42 give birth, the ASFR increases dramatically for that year, but this is not a sustained trend.

c) reduce the difference between the sum of the averaged fertility levels (Total Fertility Rate) to current TFR levels, and to consider the impact of using a too low or high starting point.

It would have been possible to base the fertility assumptions on one year of fertility data. However, due to the small numbers of births seen at either end of the age range these figures were very volatile at a local authority level.

Three further options were considered for the 2006-based projections, and these were either taking a 3-year average, a 5-year average, or a 10-year average of data. After considering the options, it was decided that using a 5-year average ASFR best met the criteria above. Using a 5-year average:

a) reduces the number of zeroes seen at the single year of age level.

b) offers a compromise between stability but allows for changes to be seen between rolling periods.

c) produces an average likely to be slightly different to the current overall fertility level. However, the benefits of the other criteria outweigh this.

For the 2011-based local authority population projections the WASP group reviewed the length of period used for the fertility assumptions considering the option of increasing the number of years on which these would be based. Evidence of birth trends over a longer period was considered. It was decided that the 5-year period should continue to be used for 2014-based projection as this continues to offer a good compromise between stability and taking account of recent birth trends. The same approach has been used for the 2014-based projections.

For the 2011-based local authority population projections five-year average ASFRs had been calculated for each local authority using mid-year population estimates for 2002 to 2010 which had been revised to take into account the results of the 2011 Census.

Calculating Scaled ASFRs based on the most recent fertility trends

For the 2006-based projections it was decided that the long-term fertility assumptions should be based on fertility levels for the most recent year in order to reflect recent trends. The 5-year average ASFRs would need to be adjusted using the calculation described below to achieve this. The same approach was used for the 2014-based projections.

Calculating the scaled ASFRs

1. The original 5-year average ASFR for those aged a in local authority L is denoted by:

$$ASFR_{[a,L]} = \frac{\sum_{y=1}^{5}\left(\left(\frac{\left(B_{[a,y,L]}\right)}{\left(\frac{MYE_{[a,y,L]} + MYE_{[a-1,y,L]}}{2}\right)}\right) * 1000\right)}{5}$$

2. A ratio R was calculated; where

$$R_{[L]} = \frac{\text{total number of births for 2010/11 for local authority L}}{\text{predicted number of births for 2010/11 for local authority L}}$$

The figure for the total number of births was provided by ONS.
The predicted number of births was obtained by applying the 5-year averaged ASFR to each local authority's estimated average population aged *a* during the mid to mid-year period to calculate births as follows:

Predicted number of births for local authority L for y to y+1

$$= \sum_{a} \frac{ASFR_{[a,L]}}{1000} * \frac{\left(MYE_{[a,y,L]} + MYE_{[a-1,y,L]}\right)}{2}$$

3. The 5-year average ASFR was then scaled using the ratio R for each local authority as follows:

$$ASFR_{[a,L]} * R_{[L]} = scASFR_{[a,L]}$$

Where *sc*ASFR is the final scaled 5-year average ASFR based on fertility levels for the most recent year, and from now on will just be referred to as the ASFR.

Using 5-year average data to distribute current fertility levels to individual ages of mother (15 to 49) continues to offer a good solution to the issues of using current fertility levels but reducing the volatility of single year of age data.

How were future changes in fertility rates accounted for?

The ASFRs were taken together with fertility data from the Wales national population projections in order to take into account future changes in fertility over time. Differentials were used to predict the pattern of fertility by age group over the projection period (with a trend towards decreasing numbers of births to younger females but increasing births to older females) and were produced using fertility data from the National Population Projections for Wales. These national-level differentials were used to predict future fertility trends at a local authority level for all local authorities in Wales.

The fertility differentials were calculated using projected ASFRs from the 2014-based Wales National Population Projections produced by ONS. The projected ASFRs were indexed on the projected ASFR data for 2014-15.

Differentials were calculated for **quinary age groups** from 15-19 up to 45-49 for each year of the projection period by:

- Multiplying the projected ASFRs by the respective year's projected population;
- Multiplying the projected 2014-15 ASFRs by the respective year's projected population;
- Calculating a ratio between the two figures above.

Further information showing how the differentials were calculated is given in Annex 1 at the end of this report.

The fertility differentials were combined with the scaled 5-year average ASFRs to form the final fertility assumptions. This ensured that the number of births corresponded with projected birth patterns in national fertility trends as well as with current local ASFRs.

3e) How were projected births distributed to males and females?

The number of 'boys born per 1,000 girls' ratio was used in the population projections to allocate a proportion of births to each sex.

Analysis of birth patterns across a number of years for all local authorities showed that there was no clear pattern in the ratio of boys to girls from one local authority to another. Therefore it was decided to use the Wales ratio of 1,050 boys per 1,000 girls for all local authorities. This is also consistent with the ratio used in the National Population Projections.

The 'boys per 1,000 girls ratio' was set to 1,050 boys per 1,000 girls for each local authority.

Calculating the projected number of births

The projected number of births was derived using the fertility assumptions described above and the population base.

The following calculation was applied to the female population to produce the projected estimate of births for local authority L for each of the projection years:

$$B_{[y,L]} = \sum_{a=15}^{49} \frac{\left(MYE_{[a,y,L]} + MYE_{[a-1,y,L]}\right)}{2} * \left(\frac{scASFR_{[a,L]}}{1000} * Diff_{[a,y]} \right)$$

B = projected births estimate for local authority L
a = age
ASFR = the age specific fertility rate based on recent fertility trends
Diff = fertility differentials

- Note that the mid year estimates of the population refer to the population at 30 June of year y.
- The estimate of births refers to the total births from 1 July of year y to 30 June year y+1.
- The differential denotes the projected fertility trend from 1 July of year y to 30 June year y+1.

4. Mortality assumptions

In order to project the number of deaths in each local authority during each year of the projection period, mortality assumptions were produced for each local authority. This section describes how these mortality assumptions were formed.

The ONS methodology adds in the base year (2014 for these projections) to make the projections more accurate, however due to the higher than expected number of winter deaths in 2014 this caused a distinct spike in the deaths data. ONS applied an upwards adjustment of 6.2 per cent for males and 8.1 per cent for females for 2014-15 (the first year of our projections). This was based on the provisional data they had for 2015 for deaths and the spike in deaths in the early part of 2015. The details are given in the ONS statistical bulletin Excess Winter Mortality in England and Wales.

Age Specific Mortality Rates (ASMRs) were used as the basis for the mortality assumptions. ASMRs are calculated for each single year of age and sex by dividing the number of deaths for age X and sex Y by the population for age X and sex Y and multiplying by 1,000.

The data source was the Vital Statistics Registration Online System which is run by the ONS.

The section below summarises the key steps that were taken to calculate the mortality assumptions. More detail is given in the sections that follow.

Key Decisions

On what time period were the mortality assumptions based?
The software used to calculate the projections is designed to use data which is on a mid-year to mid-year basis. For consistency all the data used to form the mortality assumptions were on a mid-year to mid-year basis (that is, 1 July to 30 June).

To which population group were the mortality rates applied?
The population base used for the denominator of the mortality rates was the population by single year of age and sex at the start of the mid-year to mid-year period.

What type of data about deaths was used?
Deaths data adjusted to age as at 30 June were used to form the Age–specific Mortality Rates (ASMRs).

How was data volatility dealt with?
Assumed mortality rates were derived from a 5-year average ASMR (adjusted to 2013-2014 local authority death levels) in order to reduce data volatility.

How were future changes in mortality rates accounted for?
Mortality differentials were used to take into account projected changes in mortality over time. Mortality differentials were calculated from mortality data from the 2014-based National Population Projections for Wales. They are a measure of the projected year on year change in mortality data from the national projection for Wales.

To which population group were the mortality rates applied?

ASMRs were calculated for males and females aged newborn to 90+ by single year of age for each local authority in Wales. ASMRs were calculated for each single year of age and sex by dividing the number of deaths for age X and sex Y by the population for age X sex Y and multiplying by 1,000. The ASMRs were based on mid-year to mid-year data for the most recent five years.

A population denominator is needed to calculate the five year average ASMRs. For the 2014-based projections the approach followed that used in the previous (2006-based, 2008-based, and 2011-based) projections as follows:

Population base for ASMRs:

The population aged *a* by sex at the start of mid to mid-year period

$MYE_{(a,x,y)}$

Where
- y=year
- a=age
- x=sex
- MYE= mid-year population estimate

For example the base population for the ASMR of women aged 30 for the year mid 2010-11 would be as follows:

$MYE_{(30,females,2010)}$

The mid year estimate at 30 June 2013 was used because Popgroup calculated death rates based on the **start of mid-year** population, and so this population base denoted the population of 30 year old women at 1 July 2013.

What type of data on deaths was used?

Deaths data is available in two forms – occurrences and registrations. Occurrences data records the month and/or year in which the death occurred, whereas the registrations data classifies the information to the month and/or year it was registered. For the majority of deaths the year of occurrence and registration of occurrence are the same, however there are a number of deaths occurring towards the end of the yearly period that may not be registered in the same year (see Table 1)

The occurrences data is taken a few months after the end of the mid to mid year period to allow for some of the late registrations to be included in the data. Also, for deaths investigated by a coroner there may be a longer time between occurrence and registration. Note that the data below refers to calendar years, however the same principle applies to mid-year to mid-year populations.

Table 1: Comparison showing year of death occurrence and registration, Wales, 1994 to 2006

Year of Occurrence	Year of registration													
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
1993	663	11	1											
1994	33,144	776												**33,920**
1995		34,505	1,059											**35,564**
1996			33,654	954										**34,608**
1997				33,867	773									**34,640**
1998					33,057	925								**33,982**
1999						33,881	1,154							**35,035**
2000							32,251	1,072						**33,323**
2001								32,074	919					**32,993**
2002									32,263	906				**33,169**
2003										32,737	922			**33,659**
2004											31,225	894		**32,119**
2005												31,097	1,007	**32,104**
Total	**33,807**	**35,292**	**34,714**	**34,821**	**33,830**	**34,806**	**33,405**	**33,146**	**33,182**	**33,643**	**32,147**	**31,991**		

To maintain consistency with other key vital statistics outputs in Wales it was decided that occurrences data should be used in the 2006-based projections, based on the information shown in Table 1 above. Death occurrences data were obtained by age as at 30 June from the ONS and is the same as that used in the Mid-Year Estimates. This approach has been used for subsequent sets of projections (2008-based onwards).

Calculating age at death

The death occurrences data was obtained from the ONS by single year of age as at the 30 June (the end of the mid to mid year period) as used in the mid-year estimates.

To obtain the data by age as at the 30 June, ONS adjusts the deaths data based on the month of birth and the month of death. ONS apply 3 methods:

Method 1:

If **both** the month of birth and month of death fall between January and June OR July and December then the age as at the end of the mid-year period (30 June) is calculated by taking the difference between the year of birth and the year of death.

$$Age = Y_d - Y_b$$

Where age= age at 30 June, b=births, d= deaths

Method 2:

If the month of birth falls between January and June and the month of death falls between July and December, then the age as at the end of the mid-year period (30 June) is calculated by the difference between the year of birth and the year of death and adding one.

$$Age = (Y_d + 1) - Y_b$$

Where age= age at 30 June, b=births, d=deaths

Method 3:

If the month of birth falls between July and December and the month of death falls between January and June, then the age as at the end of the mid-year period (30 June) is the same as the age at death.

To form the ASMRs it is required to use age as at the start of the mid-year (1 July -this is described in more detail in the section that follows). Therefore since deaths data is provided by age as at 30 June (i.e. end of the mid-year period) it is necessary to adjust the deaths data back one year in order to represent age at the start of the mid-year period. For deaths of people who would have been aged 0 as at the 30 June, this involves them being classified as newborns in the projections as they were not yet born at the start of the year.

The methods used by the ONS population estimates team (methods 1-3 above) have one slight disadvantage - they mis-allocate any person born on the 1 July and who dies between the months of January and June. According to the allocation completed by ONS, these deaths would be assigned to the age at death (see method 3 above).

For example, by using deaths data for the year beginning mid 2005, a baby born on the 1 July 2004 who died in March 2006 would be classified as aged 1 as at the 30 June 2006, which is correct. However if you adjust this back a year you would classify them as aged 0 as at the beginning of the year 2005 (1 July 2005) – which is incorrect as on the 1 July 2005 they would have turned 1 year of age.

The impact of this is likely to be small, and due to the small numbers involved, data is unavailable in order to carry out any adjustment for this possibility each year. Given the lack of data to adjust for this, the WASP group agreed to use the deaths data by age as at 30 June.

Calculating the Initial ASMRs

ASMR Calculation

ASMRs were calculated using the Mid Year Estimate at the start of the mid-to-mid year period to be consistent with the software. This means that the historic ASMRs were calculated as follows:

$$ASMR_{[a,x,y]]} = \left(\frac{D_{[a,x,y]]}}{MYE_{[a,x,y]]}} \right) * 1000$$

For:	D	=	deaths of people aged *a* as at 1 July 1 year y
	MYE	=	mid-year population estimate
	a	=	age at start of year
	y	=	year
	x	=	sex

Note that the mid year estimates of the population refer to the population at 30 June of year y. The deaths figure refers to the total deaths from 1 July of year y to 30 June year y+1 of people aged *a* as at 1 July year y.

For example to calculate the ASMR for women aged 30 for the year y to y+1:

The population base would be as previously shown:

$MYE_{\textbf{(30,females,2010)}}$

The ASMR would be as follows:

Figure 1

$$ASMR_{[30,f,\psi]]} = \left(\frac{\left(D_{[30,f,\psi]}\right)}{MYE_{[30,f,\psi]}} \right) * 1000$$

Where ($D_{[30,f,\psi]}$) refers to deaths of women between 1 July 2010 to 30 June 2011 who were aged 30 as at 1 July 2010.

Note that deaths data were provided by age as at 30 June each year, for example the deaths of women during 2010-11 who would have been aged 31 as at 30 June 2011.

Figure 1 requires as the numerator the deaths of women between 1 July 2010 to 30 June 2011 who were aged 30 as at 1 July 2010. Therefore as the deaths data received from ONS denoted age as at the end of the year, the deaths of women during 2010-11 who would have been aged 31 as at 30 June 2011 would be used as the numerator in this calculation, as these women would have been aged 30 as at the start of the year.

This ensures that the rates are based on the age as at the start of the mid-year period, to be consistent with the software.

More information on how the deaths rates were calculated is given in Annex 1.

How was data volatility dealt with?

In producing ASMR assumptions the aim was to:

a) reduce the number of zeroes at the single year of age level, so zeroes are only found when there is a trend for no deaths to be at that age (and therefore the ASMR is a more true zero) and this is not just a one year anomaly.

b) reduce the volatility of data at the single year of age level.

c) reduce the difference between the expectation of life calculated from the average data and the current level of expectation of life, particularly considering the impact of using a too low/ high starting point.

It would be possible to base the mortality assumptions on one year of mortality data. However, due to small numbers of deaths seen at younger ages (that is, children and young people) these figures are very volatile at a local authority level.

Three options were considered, and these were either taking a 3-year average; a 5-year average; or a 10-year average of data. After some consideration it was decided that using a 5-year ASMR average best met the criteria above. Using a 5-year average:

a) reduces the number of zeroes seen at the single year of age level.

b) offers a compromise between stability but allows for changes to be seen between rolling periods.

c) produces an average that is likely to be further away from the current overall mortality level. However, the benefits of the other criteria outweigh this.

For the 2011-based local authority population projections the WASP group reviewed the length of period used for the mortality assumptions considering the option of increasing the number of years on which these would be based. Evidence of mortality trends over a longer period was considered. It was decided that the 5-year period should continue to be used for 2014-based projections as this continues to offer the compromise between stability and taking account of recent mortality trends.

Five-year average ASMRs were calculated for each local authority using mid-year population estimates for 2010 to 2014.

Calculating Scaled ASMRs based on the most recent mortality trends

For the 2006-based projections it was decided that the long-term mortality assumptions needed to be based on mortality levels for the most recent year in order to reflect recent trends. The 5-year average ASMRs would need to be adjusted using the calculation described below to achieve this. The same approach was used for the 2014-based projections.

Calculating the scaled ASMRs

1. The original 5-year average ASMR for those aged *a* in local authority L is denoted by:

$$ASMR_{[a,x,L]} = \frac{\sum_{y=1}^{5}\left(\left(\frac{D_{[a,x,y,L]}}{MYE_{[a,x,y,L]}}\right) * 1000\right)}{5}$$

2. A ratio R was calculated; where

$$R_{[L]} = \frac{\text{total number of deaths for year y for local authority L}}{\text{predicted number of deaths for year y for local authority L}}$$

The figure for the total number of deaths was provided by ONS.
The predicted number of deaths was obtained by applying the 5-year averaged ASMR to each local authority's year y MYE population by age and sex to calculate deaths as follows:

Predicted number of deaths for local authority L for year y to y+1

$$= \sum_{a} \frac{ASMR_{[a,x,L]}}{1000} * MYE_{[a,x,y,L]}$$

3. The 5-year average ASMR was then scaled using the ratio R for each local authority as follows:

$$ASMR_{[a,g,L]} * R_{[L]} = scASMR_{[a,g,L]}$$

Where *sc*ASMR is the final scaled 5-year average ASMR based on mortality levels for the most recent year, and from now on will just be referred to as the ASMR.

Using 5-year average data to distribute current mortality levels to individual ages continues to offer a good solution to the issues of using current mortality levels but reducing the volatility of single year of age data.

How were future changes in mortality rates accounted for?

The ASMRs were taken together with fertility data from the Wales national population projections in order to take into account future changes in mortality over time. Differentials were used to predict the patterns of mortality by age group and sex over the projection period (with assumed increases in expectation of life for both males and females) and were produced using mortality data from the National Population Projections for Wales. These national-level differentials were used to predict future mortality trends at a local authority level for all local authorities in Wales.

The mortality differentials were calculated using projected ASMRs from the 2014-based Wales National Population Projections produced by ONS. The projected ASMRs were indexed on the projected 2014-15 information to produce the differentials.

Differentials were calculated for quinary age groups up to 85+ for each year of the projection period by:

- Multiplying the projected ASMRs by the respective year's projected population;
- Multiplying the 2013-14 ASMRs by the respective year's projected population;
- Calculating a ratio between the two figures above.

Further information showing how the differentials were calculated is given in Annex 1 at the end of this report.

The mortality differentials were combined with the scaled 5-year average ASMRs to form the final mortality assumptions.

This ensured that the number of deaths corresponded with projected death patterns in national mortality trends as well as with current local ASMRs.

Calculating the projected number of deaths

The projected number of deaths was derived using the mortality assumptions described above and the population base.

The following calculation was applied to produce a projected estimate of deaths for local authority L for each of the projection years:

$$D_{[a,y,L]} = \sum_{a=newborn}^{90+} \left(MYE_{[a,y,L]}\right) * \left(\frac{ASMR_{[a,L]}}{1000} * Diff_{[a,y]}\right)$$

D = projected estimate of deaths for local authority L
a = age
ASMR = the age specific mortality rate based on recent mortality trends
Diff = mortality differentials

- Note here that the mid year estimate of the population refers to population at 30 June of year y.
- The projected estimate of deaths refers to the total deaths from 1 July of year y to 30 June year y+1 of people aged a as at 1 July of year y.
- The differential denotes the projected mortality trend from 1 July of year y to 30 June year y+1.

5. Internal migration assumptions

Internal migration refers to migration moves from one local authority area in the UK to another. It does not include moves within a local authority area. In order to project the number of migration moves during each year of the projection period, internal migration assumptions were produced for each local authority.

The data source was the Components of Population Change for mid-2013 to mid-2014 and revised Components of Population Change published by the ONS in 2013. Earlier figures had been revised to take into account the results of the 2011 Census. Internal migration data is based partly on data from the Patient Register Data System (PRDS). ONS receive an annual extract of GP registration data from this system, and by comparing postcodes in two successive years of data, ONS compile internal migration estimates. Data is published on a mid to mid year basis and is published annually by sex and quinary age as at 30 June.

Key Decisions

What were the long term internal migration assumptions?
For the principal projections, data for inflows and outflows by quinary age group and sex for the 5-year period between 2009-10 to 2013-14 were averaged for each local authority, and then projected forwards as static counts for each year from 2014 to 2039, as this method offered the best stability for the long-term assumptions.

How were the quinary migration flows distributed to single year of age?
Age specific migration rates (ASMigRs) for internal migration inflows and outflows were calculated for each local authority by sex and by single year of age up to age 90+, and expressed per thousand people. The ASMigRs were then used to distribute the quinary flows to single year of age.

Assumptions for internal migration

Three options were considered for calculating the internal migration assumptions for the principal projections. These were:

1. Propensity to migrate for inflow and outflow assumptions:
2. 5-year average historic data projected forward (static migration flows for inflows and outflows)
3. A propensity model for either inflows/outflows, and a static migration assumption for the other (a combination of points 1 and 2 above).

After considering each option, it was decided to use option 2 for calculating the long term migration assumptions. Option 2 gives a fixed number of assumed migrants into each LA for every year of the projection. It is based on average migration estimates by age and sex over the 5 years up until the base year of the projection (2014). It makes no allowances for predicted changes in the UK population, but assumes a constant level of migration. Given the volatility of migration numbers and rates year on year, a 5-year average helps to smooth this volatility, producing a stable long term assumption.

As a result the internal migration assumptions for inflows and outflows were derived by calculating the average number of migrants by sex and quinary age group (up to 75+) from data for 2009-10 to 2013-14. These assumptions were then applied as counts for each local authority for each year of the projection period.

It was decided that 5-year average static migration inflows and outflows by quinary age and sex from 2009-10 to 2013-14 should be used for the principal projection as this offered the best stability for the long-term assumptions, whilst taking account of recent migration trends. Two variant projections have been produced, however:

- A *zero migration* (natural change only) projection to illustrate the projected population of each local authority if there were no future inward or outward migration.
- A variant in which the migration assumption is based on the average migration over a longer, 10-year period, i.e. 2004-05 to 2013-14.

Using age-specific migration rates to distribute the quinary flows to single year of age

It was decided that 5-year average quinary age flows by sex were to be used as the long-term static migration assumptions for the Local Authority Population Projections, however there was a need to distribute these quinary flows to single year of age.

Therefore 5-year average age specific migration rates (ASMigRs) for internal migration were calculated for each local authority by sex and by single year of age up to age 90+, and expressed per thousand people as shown on the next page.

The ASMigRs were calculated as follows:

Inflows and outflows for each individual year from 2006-07 to 2010-11 by age, sex, and local authority were divided by the population of the local authority by age and sex for that year. These were then averaged and expressed as a rate per thousand.

Internal in-migration ASMigRs:

$$ASMigR_{a,x,L} = \frac{\sum_{Y=2006}^{2010}\left(\frac{Inflows_{a,x,L}}{MYE_{a,x,L}}\right)}{5} * 1000$$

Internal out-migration ASMigRs:

$$ASMigR_{a,x,L} = \frac{\sum_{Y=2006}^{2010}\left(\frac{Outflows_{a,x,L}}{MYE_{a,x,L}}\right)}{5} * 1000$$

Where

MYE	=	Mid year estimate
Y	=	Year
L	=	local authority
a	=	age as at the start of the year
x	=	sex

In the same way as for the mortality assumptions, the rates above are calculated by age as at the start of the mid-year. Internal migration data denotes migration during the mid-year period to migrants age *a* at the end of the mid-year (30 June).

Therefore to calculate internal in-migration rates to women aged 30 from 2010-11:

$$ASMigR_{30,f,L} = \frac{\sum_{Y=2006}^{2010}\left(\frac{Inflows_{30,f,L}}{MYE_{30,f,L}}\right)}{5} * 1000$$

The formula requires as the numerator the migration of women who were aged 30 as at 1 July in a given year. Therefore as the internal migration data received from ONS denotes age as at the end of the year, the migration of women who would have been aged 31 as at 30 June of a given year would be used as the numerator in this calculation, as these women would have been aged 30 as at the start of the year.

This ensures that the rates are based on the age as at the start of the mid-year period, to be consistent with the software.

More information on how the migration rates were calculated is given in Annex 1.

It is easiest to demonstrate how these ASMigRs are used to distribute the quinary flows to single year of age by using an example. The process is the same for inflows and outflows.

Take the quinary age group 5-9 for local authority L.

In order to estimate the number of migrants aged 7 in this age group from 1 July year y to 30 June year y+1, the following calculation is applied:

(Given 5-year annual average female migrants aged 5-9 in local authority L from 2006-07 to 2010-11)*[(Expected female migrants aged 7 in local authority L as at 30 June year y)/(Expected female migrants aged 5-9 in local authority L as at 30 June year y)]

Where:

Expected female migrants aged 7 in local authority L as at 30 June year y = $(ASMigR_{7,f,L} * MYE_{y,7,f,L})$

Expected female migrants aged 5-9 in local authority L as at 30 June year y = $\sum_{a=5}^{9}(ASMigR_{a,f,L} * MYE_{y,a,f,L})$

Note here that the mid year estimate of the population refers to population at 30 June of year y.

6. International migration assumptions

International migration refers to migration moves between a local authority in Wales and overseas (that is, outside the UK). It does not include moves within the UK. However, a person is only classified as an international migrant if they migrate or intend to migrate for 12 months or more. Migrants who at the time of migration, do not intend to stay for 12 months or more are classified as short-term migrants and are not included in the migration figures. An adjustment is made for people whose actual length of stay is different to their intention at the time of migration (either under 12 months to over 12 months or vice versa). In order to project the number of migration moves during each year of the projection period, international migration assumptions were produced for each local authority.

The data source was the Components of Population Change for mid-2013 to mid-2014 and revised Components of Population Change for mid-2005 to mid-2013 published by the ONS on 30 April 2016. Within this international migration movements are estimated by combining data from the International Passenger Survey (IPS), Home Office data on asylum seekers and visitor switchers and migration to and from the Republic of Ireland.

Key Decisions

What were the long-term international migration assumptions?
For the principal projections, data for inflows and outflows by quinary age groups and sex for the 5-year period between 2009-10 to 2013-14 were averaged for each local authority, and then projected forwards as static counts for each year from 2014 to 2039, as this method offered the best stability for the long-term assumptions.

How were the quinary flows distributed to single year of age?
Age specific migration rates (ASMigRs) for international migration were calculated for each local authority by sex and by single year of age up to age 90+, and expressed per thousand people. The ASMigRs were then used to distribute the quinary flows by single year of age.

Assumptions for international migration

For the 2006-based projections three options were considered for calculating international migration. These were:

1. Propensity to migrate for inflow and outflow assumptions:
2. 5-year average data projected forward (static migration flows for inflows and outflows)
3. A propensity model for either inflows/outflows, and a static migration assumption for the other (a combination of points 1 and 2 above).

After considering each option, it was decided to use option 2 for calculating the long term international migration assumptions. This approach was used for the 2006-based and subsequent sets of projections. Option 2 gives a fixed number of assumed migrants into each LA for every year

of the projection. This is based on average migration estimates by age and sex over the 5 years up until the base year of the projection (2014). It makes no allowances for predicted changes in the UK population, but assumes a constant level of migration. Given the volatility of migration numbers and rates year on year, a 5-year average helps to smooth this volatility, producing a stable long term assumption.

The in and out international migration assumptions were derived by calculating the average number of migrants by sex and quinary age group (up to 75+) from the 5-year averaged data from 2009-10 to 2013-14. These assumptions were then applied as counts for each local authority for every year of the projection period from the year beginning 1 July 2014 onwards.

It was decided that 5-year average static migration inflows and outflows by quinary age and sex from 2009-10 to 2013-14 should be used for the principal projection as this offered the best stability for the long-term assumptions. Two variant projections have been produced, however:

- A *zero migration* (natural change only) projection to illustrate the projected population of each local authority if there were no future inward or outward migration.
- A variant in which the migration assumption is based on the average migration over a longer, 10-year period, i.e. 2004-05 to 2013-14.

Using age-specific migration rates to distribute the quinary flows to single year of age

It was decided that 5-year average quinary age flows by sex were to be used as the long-term migration assumptions for the Local Authority Population Projections, however there was a need to distribute these quinary flows to single year of age.

Therefore 5-year average age specific migration rates (ASMigRs) for international migration were calculated for each local authority by sex and single year of age up to age 90+, and expressed as a rate per thousand people.

Propensity to migrate models

Such models consider the probability of a person moving from area X to area Y.

The WASP group considered the work that had been undertaken by the Office for National Statistics in reviewing the setting of migration assumptions for the National Population Projections. One of the recommendations of the review was to consider using propensity to migrate models for the National Population Projections. ONS decided not to implement this recommendation for its next set of National Population Projections (2012-based) but to reconsider for future projections.

Bearing this in mind the WASP group concluded that it would not try to implement such a change for these 2014-based projections. It would, however, continue to follow the ONS work on this and would assess the feasibility of using propensity to migrate models in future.

The ASMigRs were calculated as follows:

Inflows and outflows for each individual year from y to Y+4 by age, sex, and local authority were divided by the population of the local authority by age and sex for that particular year. These were then averaged and expressed as a rate per thousand.

International in-migration ASMigRs:

$$ASMigR_{a,x,L} = \frac{\sum_{Y=y}^{y+4}\left(\frac{Inflows_{a,x,L}}{MYE_{a,x,L}}\right)}{5} * 1000$$

International out-migration ASMigRs:

$$ASMigR_{a,x,L} = \frac{\sum_{Y=y}^{y+4}\left(\frac{Outflows_{a,x,L}}{MYE_{a,x,L}}\right)}{5} * 1000$$

Where

MYE	=	Mid year estimate
Y	=	Year
L	=	local authority
a	=	age
x	=	sex

Unlike the internal migration data, the international migration data is only available by age as at migration, and not by age as at the end of the mid-year period. Therefore no adjustment is needed to calculate rates for age as at the start of the mid-year. Instead, age as at the start of the mid-year is assumed to be the same as age at migration.

More information on how the migration rates were calculated is given in Annex 1.

Again it is easiest to demonstrate how these ASMigRs are used to distribute the quinary flows to single year of age by using an example. The process is the same for inflows and outflows.

Take the quinary age group 5-9 for local authority L.
In order to estimate the number of migrants aged 7 in this age group from 1 July year y to 30 June year y+1, the following calculation is applied:

(Given 5-year annual average female migrants aged 5-9 in local authority L from 2009-10 to 2013-14)*[(Expected female migrants aged 7 in local authority L as at 30 June year y)/(Expected female migrants aged 5-9 in local authority L as at 30 June year y)]

Where:

Expected female migrants aged 7 in local authority L as at 30 June year y = $(ASMigR_{7,f,L} * MYE_{y,7,f,L})$

Expected female migrants aged 5-9 in local authority L as at 30 June year y = $\sum_{a=5}^{9}(ASMigR_{a,f,L} * MYE_{y,a,f,L})$

Note here that the mid year estimate of the population refers to population at 30 June of year y.

7. Special population groups

Special population groups are sub-sets of the population that have specific age structures which are fairly constant over time. Special population groups are not usually captured within either internal or international migration. Such populations are also known as 'static populations'.

As these groups have fairly static age structures, the projections model of ageing-on would not be appropriate (for example, a 45-year old soldier at a barracks would be 65 within 20 years, and therefore no longer in the services which is not appropriate).

To prevent the ageing on of these populations:

- special populations (by age and sex) are removed at the start of each year of the projection
- the projections model is applied to the remaining population
- the special populations (by age and sex) are added back in at the end of the process for each year of the projection period. (See part 2)

The special populations used in the projections

The following were considered as special population groups in the Local Authority Population Projections for Wales:

- Home Armed Forces
- Prisoners

No prisons are located in National Park areas and of the other affected areas prisoners are resident in Monmouthshire only. As a result an assumption was made for special populations for the Residual Area of Monmouthshire based on the assumed special population count for the whole of Monmouthshire used in the 2014-based Local Authority Population Projections. This in turn was based on ONS data for mid-2014. Due to a lack of data for armed forces this population group has been excluded from both National Parks and Residual Areas.

Armed forces data

Information on UK (or Home) armed forces is collected via the Defence Analytical Services Agency (DASA). These figures include the numbers of home armed forces and their dependants resident in each local authority.

The data was input into the software by single year of age and sex for the home armed forces.

Foreign Armed Forces were not treated as a special population within the Wales sub-national population projections. This was due to a number of factors:

- Permission to gain access to the foreign armed forces data from the US Air Force was not granted;

- There are negligible numbers of foreign armed forces and their dependents within Wales. However Foreign Armed Forces are included in the base population of the mid year estimates.

Prisoners data

Data on prisoners is collected by the Home Office. Figures are supplied to ONS by the Home Office for use in the mid-year estimates. The Home Office supplies data on the number of prisoners resident in each prison on 30 June by age and sex. The Population Estimates Unit allocates each prisoner to an LA, based on the postcode of the prison and then aggregates the data by age and sex to the LA level.

There are four prisons in Wales and these are located in Cardiff, Monmouthshire, Bridgend, and Swansea; they are male prisons. Therefore data was input into the software for males by single year of age for these four prisons.

A 3-year average is used for the 2014-based prisoner population. Earlier projections used a 5-year average. The change was because ONS changed their calculations for prisoners; previously it was those who had served 6 or more months but it was changed to include those serving 6 months or more irrespective of how far into the sentence they were. That is, someone one week into a one-year sentence would not have previously been included: now they would be included. Using the 5-year average would have meant that two different definitions would have been used in the same time period.

For all the above special populations, 2013-14 data was used as this was the most up to date data available. This data was projected forward as static counts throughout the projection period.

Summary – Special Populations

- Special population groups are sub-sets of the population that have specific age structures, which are fairly constant over time. Special population groups are not usually captured within migration (both internal and international) estimates.

- The following were considered as special population groups in the Wales sub-national projections:
    1. Home Armed Forces
    2. Prisoners

  For the National Parks projections armed forces populations were not taken into account because of a lack of data.

- Information on UK (or Home) armed forces is collected via the Defence Analytical Services Agency.

- Data on prisoners are collected by the Home Office.

- For the above special populations, 2010-11 data was used as this was the most up to date data available. This data was projected forward as static counts throughout the projection period.

Note on unattributable population change

As part of the components of change data provided with the population estimates which had been revised based on the 2011 Census an element was included for ‘unattributable population change’. The ONS guidance indicated that this element, produced by the exercise to reconcile the 2011 Census with previous population estimates, could not be assigned with certainty to migration or changes to the population base and was a one-off change.

The WASP working group looked at whether the unattributable change could be taken into account when running the population projections, and a breakdown of the data by age and sex was obtained for analysis. It was felt that there was no way of identifying where this change had come from and use of the information in the population projections would assume that the projections are wrong by the same amount as the unattributable change. The group also concluded that inclusion of an element for unattributable change in the projections would be difficult to explain. As a result in the 2014-based projections no assumption has been made for unattributable population change.

8. National Parks projections

These projections provide estimates of the future populations of the three National Parks in Wales: the Brecon Beacons, the Pembrokeshire Coast, and Snowdonia. They are based on a similar methodology to the 2014-based Local Authority population projections. National parks are not standard geographies used for presenting statistics by ONS and other government departments.

For the National Park projections, fertility, mortality, and migration data was obtained from ONS for the three National Parks and used to form assumptions. The methodology only differed from that used for the local authorities when the required data was not available at a National Park level. For example, a lack of data means that armed forces are not taken into account in either National Parks or Residual Areas, and international migration is estimated rather than being based on collected data.

All figures relating to working age and pensionable age populations are based on the state pension age for the given year. Between 2010 and 2020, state pension age will change from 65 years for men and 60 years for women, to 65 years for both sexes. Between 2024 and 2046, state pension age will increase in three stages from 65 years to 68 years for both sexes.

There are no POPGROUP Data Modules for the national parks, so it is necessary to locate and enter the relevant data from the Census and from mid-year estimates. It is generally accepted that patterns of fertility, mortality, and migration are generally quite stable and do not change rapidly. The assumption has been made that fertility, mortality, and migration levels are the same for the parts of the National Parks as the local authorities that those parts lie within.

National Parks residual areas

The Pembrokeshire Coast National Park lies entirely within the Pembrokeshire local authority. Snowdonia is partly in Gwynedd and partly in Conwy. The Brecon Beacons fall within Powys, Monmouthshire, Carmarthenshire, Rhondda Cynon Taf, and Merthyr Tydfil. To be strictly accurate very small parts of the National Parks lie in other local authorities but these areas are so small that they can be ignored for the residual calculations.

So several local authorities lie partly inside a National Park and partly outside. The area that lies outside is known as a residual area.

The residual areas for local authorities A and B are the cross-hatched areas. The word residual is generally used to suggest a small part of something, but in this context the population of a local authority residual area is much larger than the population of the National Park area which lies inside the local authority.

This is a summary of the method used to calculate the populations of these residual areas.

The population base for the area of Pembrokeshire outside the Pembrokeshire Coast National Park area was calculated by subtracting the published population estimate for the National Park from that for the local authority for mid-2014. This was done by single year of age and sex.

The population base for Residual Areas outside Brecon Beacons and Snowdonia National Parks was calculated by:

- Aggregating the local authority populations for the relevant areas.
- Subtracting the National Park population from the aggregated total.
- Dividing the remainder in proportion to the population in census Output Areas (OAs) wholly outside the National Park for the relevant areas (LSOA populations were used previously).

These calculations were made by single year of age and sex.

Fertility

Birth data by age of mother were supplied by ONS by five year age band for both National Parks and Residual Areas for the five year period up to mid-2014. These were broken down by single year of age for females aged 15 to 49 using birth data for the 5 years up to mid-2014 for the relevant areas. For Residual Areas the 'relevant areas' were the local authority as a whole. For National Parks the relevant areas were as follows (this was agreed with the WASP Group):

Area	*Relevant Area*
Brecon Beacons	Powys and Carmarthenshire combined
Pembrokeshire Coast	Pembrokeshire
Snowdonia	Conwy

For the Brecon Beacons, Powys and Carmarthenshire were used as most of the National Park lies within these two areas. For Snowdonia data for Conwy were used due to the effect of student population on birth trends for Gwynedd.

The resulting births by single year of age for each year up to mid-2014 were divided by the population for the relevant year for females aged 15 to 49. For Residual Areas the population was calculated using the approach outlined above for the five years up to mid-2014. For National Park areas the published population for females by single year of age was used. The resulting age-specific fertility rates were then averaged over the five-year period up to mid-2014 and used as the starting rates for the projections. Projected trends were calculated using index values based on the 2013-based National Population Projections for Wales as per the 2014-based Local Authority Population Projections for Wales. This method should be improved by aligning the base year of the projections in the future.

Mortality

Similarly, death data were supplied by ONS by five year age band for both National Parks and Residual Areas for the five year period up to mid-2014. These were broken down using death data for the 5 years up to mid-2012 for the relevant areas as outlined above.

The resulting deaths by single year of age for each year up to mid-2014 were divided by the population for the relevant year by single year of age and sex. For Residual Areas the population was calculated using the approach outlined above for the five years up to mid-2013. For National Park areas the published population by single year of age was used. The resulting age-specific mortality rates were then averaged over the five-year period up to mid-2013 and used as the starting rates for the projections. Unlike the local authority projections they were not scaled as actual data for the year to mid-2015 were not available to compare with projected deaths produced using this method. Projected trends were calculated using index values based on the 2013-based National Population Projections for Wales as per the 2014-based Local Authority Population Projections for Wales.

Migration

For Residual Areas assumed figures for all migration with no breakdown for internal or international migration using the following approach:

- Calculate aggregate migration for local authorities which contain a National Park ('relevant areas')
- Subtract migration for National Parks (see below)
- Distribute the remainder based on the proportion of aggregate migration for each relevant area

These calculations were made by single year of age and sex. As Pembrokeshire Coast is wholly within Pembrokeshire only steps 1 and 2 were used.

Internal migration flows for National Park areas were provided by ONS averaged over five years based on flows to and from England and Wales only. For international migration to National Park areas assumed figures were calculated using the following approach:

- Calculate age-specific migration rates for relevant areas using population and international migration in- and out-flows from published components of change data
- Multiply these by the National Park population estimates for the same period.
- Average them over the five year period up to mid-2014

The results of this were subtracted from aggregate migration figures for relevant areas and combined with the ONS data to provide an assumption for all migration to National Park areas. The migration assumptions can be variable because of economic or social circumstances.

Special populations

No prisons are located in National Park areas and of the other affected areas prisoners are resident in Monmouthshire only. As a result an assumption was made for special populations for the Residual Area of Monmouthshire based on the assumed special population count for the whole of Monmouthshire used in the 2012-based Local Authority Population Projections. This in turn was based on ONS data for mid-2012.

Due to a lack of data for armed forces they are not taken into account in either National Parks or Residual Areas.

9. Use of administrative data for population projections

The Local Authority and National Park projections use ONS administrative data.

ONS quality and methodology information reports for the population theme.

The reports contain information on the methods used to compile the data for the named output and on the quality of that data. They are designed to give information on the strengths and limitations of the data so that decisions can be made on the appropriate uses of the data. ONS has the responsibility for assuring the quality of administrative data for use in official statistics.

The administrative data used in the projections has been subject to internal checks for consistency and plausibility by the Welsh Government. As a key user and producer of statistics in future the Welsh Government will give further consideration with ONS to how it can contribute to the quality assurance process around these data sources.

Birth statistics are based on the number of births occurring in a given year. They present data on births that occur and are then registered in England and Wales. Statistics are based on information collected at birth registration. Annual data are released in a series of theme-specific packages, usually between July and December. Annual birth statistics for the UK and its constituent countries are published in the 'vital statistics: population and health reference tables'.

ONS birth statistics are based on registrations provided by the General Register Office (GRO). The data represent a legal record, making it the best and most complete data source.

As part of the birth registration process, before data are submitted through the Registration Online system for births and deaths (RON), the registrar asks the informant to verify that all data entered are accurate. The registrar is then able to correct any errors. There are some validation checks built into RON to help the registrar with this process. Information supplied at birth registration is generally believed to be correct since wilfully supplying false information may render the informant liable to prosecution.

When ONS receive birth registrations, a number of checks are carried out on records to ensure that they are valid. Checks are more frequent on those records with extreme values for main variables (such as age of mother and age of father) as these have a greater impact on published tables. Any birth records which appear questionable are raised with the GRO on a monthly basis for further investigation. Any proposed changes to the recording and collection of birth registration data are carefully managed and involve ONS, GRO, and other stakeholders. This ensures that any implications on birth statistics are taken into full consideration.

Changes recently made to the Population (Statistics) Act 1938 mean that improved data on previous children has been collected since May 2012. The changes will improve the accuracy of birth statistics by birth order and feed into estimates for family size and measures of fertility.

ONS carry out quarterly checks on the births dataset.

The Births and Deaths Registration Act (1836) made it a legal requirement for all deaths to be registered from 1 July 1837. Mortality statistics for England and Wales are based on the

information collected when a death occurs and is then registered. Published figures represent the number of deaths registered in a reference period.

The annual mortality statistics cover England and Wales. The Annual Time Series Data table in the 'vital statistics: population and health reference tables' provides a range of mortality statistics for the UK and its constituent countries, with some measures available back to 1838.

Daily extracts of death registrations from RON are received by ONS and then pass through a series of automatic validation processes which highlight any inconsistencies. The Mortality Metadata provides detailed information on the collection, processing, and quality of mortality data for England and Wales.

Internal consistency checks are then conducted to eliminate any errors made during the recording of deaths, and to ensure the annual dataset is complete. Before becoming usable for analysis the data pass through more validation checks and processes, these include running frequency counts on a range of variables, checking the plausibility of combinations of fields, and checking inconsistencies. Suspect records are referred back to register offices. Any concerns relating to cause of death are referred to a Medical Advisor or Medical Epidemiologist.

There is an issue relating to the registered location of stillbirths. That is, the figures are based on the area of usual residence of mother rather than where the stillbirth took place. This is an issue for England and Wales and is in the process of being resolved by ONS and the Department of Health. Having looked into it as part of the ongoing quality work between the Welsh Government and ONS it is now clear that the issue does not affect the projections for Wales or England.

Long-term international and internal migration estimates at local authority level for England, Wales, Scotland and Northern Ireland are produced by ONS, NRS, and NISRA for the purpose of producing a range of population estimates. The data are presented as:

- Long-term international immigration and emigration volumes – representing the number of people arriving in the UK or leaving the UK for a period of at least 12 months.
- Internal in-migration and out-migration volumes - an estimate of migration within the UK (crossborder flows between each of the constituent countries, as well as migration between local authorities).
- Long-term international and internal migration turnover rates (such as volume of movement between in- and out-migration) per 1000 (of the total population)
- Long-term international inflow and outflow rates per 1000 (of the total population)
- Total volume of migration per 1000 (the sum of internal and international migration). This indicates more clearly the areas with high levels of population turnover

The assumptions for the flows between UK countries are set by ONS as rates instead of fixed numbers of migrants. Annual age- and sex-specific migration rates for each UK cross-border flow are calculated as the number of migrants at the end of the year divided by population of the country of origin at the start of the year. An average of the rates for the last 5 years of actual data

(currently year ending mid-2012 to year ending mid-2016) is then taken and applied to the population of the UK country of origin at the beginning of each projection year to calculate the projected number of migrants for each flow.

The fluctuations occurring in the earlier years are due to the new method taking into account the underlying age and sex structure and population size of the countries. The underlying age and sex distributions for cross-border migration are based on data from NISRA, NRS, and ONS.

Assumptions of future international migration have been derived from modelling recent trends in civilian migration to and from the UK. Migrants are defined as individuals who change their country of usual residence for a period of at least a year, so that the country of destination becomes the country of usual residence.

International migration figures are derived from a number of sources. The principal source is the International Passenger Survey (IPS). Adjustments are made to account for people who enter or leave the country initially for a short stay but subsequently decide to remain for a year or more (known as visitor switchers), and for people who originally intend to be migrants but in reality stay in the UK or abroad for less than 1 year (known as migrant switchers). Flows to and from the Republic of Ireland, taking into account the discontinuity in 2008 due to methodological changes, are included in the IPS flows. The IPS also excludes most, but not all, people seeking asylum. Estimates of the flows of asylum seekers (and their dependants) not captured by the IPS are obtained from Home Office data. The ONS long-term international migration table which gave the migration figures for 2001 to 2011 has been discontinued. Since the last publication of this table a more accurate source for estimates of mid year long-term migration estimates at a regional level has been identified. As part of the ongoing quality work between the Welsh Government and ONS the Welsh Government has set up a group of contacts in ONS and the Home Office to ensure that the most up-to-date data sources for Wales are used for internal migration, short-term and long-term international migration, refugees, and asylum seekers.

A new method for calculating cross-border migration assumptions is being implemented by ONS for future national population projections. The assumptions for the flows between the countries of the UK are now set as rates which are based on National Health Service Central Register (NHSCR) trend data from the previous 5 years. Annual age and sex-specific migration rates for each cross-border flow are calculated as the number of migrants at the end of the year divided by population of the country of origin at the start of the year. An average of the rates for the last 5 years of actual data is then taken and applied to the population of the country of origin at the beginning of each projection year to calculate the projected number of migrants for each flow. The main advantage of applying rates for cross-border migration is that the migrant flows are linked to the changing underlying population size and age structure. This means that the projections cannot produce implausible values, such as negative population stocks, when projected fixed levels of emigration are greater than the initial population size.

An adjustment has also been applied to the rates to take the population of the country of destination into account, ensuring that net migration levels between countries of the UK are

stabilised over the course of the projection. More detail can be found in the cross-border methodology document on the ONS website.

Short-term international migration estimates at local authority level for England and Wales are

produced by ONS. The data consists of short-term international immigration volumes, representing the number of people who stayed in England and Wales for a period between 3 and 12 months.

The coverage of international migrants joining an administrative source will depend on the purpose of the particular administrative system and will invariably differ between sources.

Household projections

Household projections provide estimates of the future numbers of households and of the numbers of people who live in them, and are based on population projections and a range of assumptions about household composition and characteristics.

Household projections are used for planning the supply of services, to estimate the future need for services, and to identify population trends that contribute to the context for future policy developments; and particularly for the planning of housing.

A household is defined as:

- One person living alone, or
- A group of people (not necessarily related) living at the same address who share cooking facilities and share a living room or sitting room or dining area.

This includes:

- Sheltered accommodation units in an establishment where 50 per cent or more have their own kitchens (irrespective of whether there are other communal facilities),
- All people living in caravans on any type of site that is their usual residence. This will include anyone who has no other usual residence elsewhere in the UK.

Average Household Size, measured in terms of persons per household provides a headline measure of household composition and is useful for comparisons over time and between different geographic areas. It is calculated by dividing the private household population by the number of households.

Various models used elsewhere were considered for the initial 2009 project for producing household estimates and projections, including dynamic and static models. Dynamic models focus on processes of changes in households populations over time by age and sex (that is, by cohort) and static models use information from discrete points in time (that is, period data).

Dynamic models are computationally complex and often require large longitudinal data sets which can be difficult to obtain. The complexity of the models does not necessarily translate to significantly more useful projections relative to the time and cost of production and means the methods tend to be less transparent. Static models tend to be simpler by comparison and are easier for users to understand. Because of this, from an early stage the initial 2009 project to

produce household projections for Wales concentrated on static models including propensity models and the average household size method.

Propensity models are used to calculate household numbers by applying household formation rates to population data. Formation rates can be calculated by age and sex using census data on households heads or household reference person ('headship' rates), or all members of each household ('membership' rates). Alternatively the average size method applies an average household size to total population numbers in order to calculate numbers of households. A propensity model which uses membership rates was chosen to produce the 2006-based household projections for Wales. Membership rates are the calculation of the likelihood of a person of a particular age and sex to be a member of each type of household. The membership rate model uses historical data on the age and sex of each household member, to calculate historical membership rates for all types of household by age and sex. These historical membership rates are projected for future years and applied to projected population numbers in order to calculate projected numbers of households.

Headship rates are based on census counts of persons who are the head or the household representative for each household. The definition of 'head' and 'household representative' can change between censuses. The methods for counting household members by age and sex were considered to be more likely to remain consistent by comparison. Also membership takes into account not just the head but all members of households. As a result the membership model was considered a safer and more robust methodology than the headship model. Whilst the average household size method is simpler to understand than propensity models, it does not take account of variations in household formation which occur by age and sex and as a result, this method was also discounted.

Projected household membership rates are applied to a projection of the private household population disaggregated by age, sex, and marital status. The method uses a simplified three-way relationship categorisation to represent marital or cohabitational status. The categories are people in couples (including married couples who are living together and cohabiting couples); separated marrieds, divorced and widowed not in couples; and people not in couples (not cohabiting, never married).

The 2001 Census and 2011 Census were used to derive household representative rates. The 2011 Census used a different definition of the household representative compared with the historic estimates of household formation. Household representative rates for 2011 have been derived using the aggregate household representative rates by marital status from the 2011 Census; household population by age, sex, and marital status from the 2011 Census; and previous household projections. This enables the 2011 Census point to be added to the esitmation process for Stage One. This approach means that the household projections are consistent with the available information on aggregate household representatives from the 2011 Census.

The household representative rates can be represented algebraically for any year as:

$$HH_{total} = \sum_{a=0-4}^{85+} \sum_{s=m}^{f} \sum_{r=c}^{s} HrR_{asr} . HP_{asr}$$

Where: HH is the number of households
HRR is the household representative rate
HP is the household population
a are age groups (0-4….85+)
s is male or female
r is marital/relationship status

Adjusted membership rates are applied to the total private household population to give the private household population by household type.

As household types are determined by size the projected numbers of persons by household type were divided by household size (that is, 1-person, 2-person, …) to give the number of households by age, type, and sex. By definition, the number of people in household types with a household size 5 or more people could vary. So for these types an average household size figure was calculated for each household type using Wales-level data from the 2001 census. Then the projected number of people in each household type was divided by this average household size figure to give the number of households by age, type, and sex for these larger household types.

The results of the previous stage were then summed by age and sex to give projected household numbers by household type for each year of the projection.

Average household size is in effect a headline measure which can be used to compare household growth in Wales over time, between projections, and with other geographical areas. Once projected numbers of households are known, average household size is calculated by dividing the projected private household population by the total number of households for each year.

10. Further Information

Local Authority Population Projections

Data cubes are available on the StatsWales website.

National Park Population Projections

Data cubes are available on the StatsWales website.

National Population Projections for Wales

Data cubes are available on the StatsWales website.

Household Projections

A set of 2011-based Household Projections for Wales have been produced based on these 2011-based Local Authority Population Projections.

Data cubes are available on the StatsWales website.

Contact details

For queries on the sub-national projections, or for general queries on the methodology used, please contact:

Population and Demography Statistics

Knowledge and Analytical Services

Welsh Government

Cathays Park

Cardiff, CF10 3NQ

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ANNEXE 1: further detail on the rates used in the 2014-based projections

This annex provides further detail on the calculations undertaken to form the mortality and migration rates in the 2014-based Local Authority Population Projections for Wales. The annex also describes how the fertility and mortality differentials were calculated.

The projections model is run using Excel-based software called Popgroup.

Note that Popgroup requires the mortality and migration rates to be based on the population at the start of the mid year, and therefore this is taken into account in the rates calculations, which are described in detail in the sections that follow.

Mortality rates

- In order to form the mortality assumptions, ASMRs are required for males and females for single year of age from newborn, age 0, age 1, ….up to age 90+.
- Popgroup requires death rates by **age at the start of the mid year**, and so rates had to be calculated based on age as at the start of the mid year.
- In the context of Popgroup, rates for those aged 0 at the start of the year refers to those that had been born but had not yet reached their first birthday at the start of the mid-year period. 'Newborn' refer to those that had not yet been born at the start of the mid year period.
- ASMRs were calculated using the Mid Year Estimate at the start of the mid-to-mid year period to be consistent with the software. This means that the historic ASMRs were calculated as follows:

$$ASMR_{[a,x,y]]} = \left(\frac{D_{[a,x,y]]}}{MYE_{[a,x,y]]}} \right) * 1000$$

For:

D	=	deaths of people aged a as at 1 July year y
MYE	=	mid-year population estimate
a	=	age at start of year
y	=	year
x	=	sex

- Note that the mid year estimates of the population refer to the population at 30 June of year y. The deaths figure refers to the total deaths from 1 July of year y to 30 June year y+1 of people **aged *a* as at 1 July year y.**

Example 1

- For example to calculate the ASMR for women aged 30 for the year 2010-11 the ASMR would be:

$$ASMR_{[30,f,2010/11]} = \left(\frac{\left(D_{[30,f,2010/11]}\right)}{MYE_{[30,f,2010]}} \right) * 1000$$

Where ($D_{[30,f,2010/11]}$) refers to deaths of women between 1 July 2010 to 30 June 2011 who were aged 30 as at 1 July 2010.

We received deaths data by **age as at the end of the mid year**, and therefore to calculate the numerator of the mortality rates, deaths data for women who would have been aged 31 as at 30 June 2011 was used. This is because these women would have been aged 30 as at 1 July 1 2010 (the start of the mid year).

Example 2

- To calculate the ASMR for female newborns for the year 2010-11 the ASMR would be:

$$ASMR_{[newborn,f,2010/11]} = \left(\frac{\left(D_{[newborn,f,2010/11]}\right)}{MYE_{[newborn,f,2010]}} \right) * 1000$$

Where:

- Newborns in Popgroup relate to those who have not yet been born as at the start of the mid year.
- The deaths data in the numerator refers to females who have not yet been born at the start of the mid year, and so deaths data for females aged 0 at the end of the mid year was used for this, i.e. deaths of females aged 0 as at 30 June 2011. This is because these females would not yet have been born as at the start of the year which is what Popgroup requires.
- There is no MYE estimate available for newborns, and so births data from 2010-11 were used to proxy the population of those who had not yet been born at the start of the mid year.

Migration

- Age Specific Migration Rates were needed in Popgroup by sex for ages newborn, age 0, age 1,…up to age 90+.
- Age Specific Migration Rates were only used in Popgroup to distribute the assumed long term inflows/outflows inputted by quinary age into single year of age.
- The internal and international migration ASMigRs were calculated as follows for the 2011-based projections:

- For the 2011-based projections, inflows and outflows for each individual year from 2006-2007 to 2010-11 by age, sex and local authority were divided by the population of the local authority by age and sex for that particular year. They were then be averaged and expressed per thousand population.
- In-migration ASMigRs:

$$ASMigR_{a,x,L} = \frac{\sum_{Y=2006}^{2010} \left(\frac{Inflows_{a,x,L}}{MYE_{a,x,L}} \right)}{5} * 1000$$

- Out-migration ASMigRs:

$$ASMigR_{a,x,L} = \frac{\sum_{Y=2006}^{2010} \left(\frac{Outflows_{a,x,L}}{MYE_{a,x,L}} \right)}{5} * 1000$$

Where

MYE	=	Mid year estimate
Y	=	Year
L	=	local authority
a	=	age as at the start of the year
x	=	sex

- However there were slight differences in the way that these rates were calculated for internal and international migration rates, and these are described below.

Internal migration

- For internal migration, internal migration inflows and outflows are received by **age as at the end of the mid year**, the same as that received for the deaths data.

Example 3

- Therefore in the 2014-based projections, to calculate the 5 year average internal ASMigRs for inflows of men aged 30 between 2010-11 to 2013-14:

$$ASMigR_{30,m,L} = \frac{\sum_{Y=2006}^{2010} \left(\frac{Inflows_{30,m,L}}{MYE_{30,m,L}} \right)}{5} * 1000$$

Where L= local authority

- Note that *Inflows*$_{30,m,L}$ above refers to the inflows of men aged 30 as at the start of the mid year (1 July year y). Therefore since the internal migration data is received by age as at the end of the mid year, then the numerator in the migration rate above uses the inflows of men who were aged 31 as at the end of the mid year (30 June year y+1), because we know that they would have been aged 30 as at the start of the mid year, as required in the calculation. This is similar to how the death rates were calculated.
- The rates for newborns are calculated in a similar way, and births data were used to proxy the denominator of the ASMigRs for newborns.

International migration

- For international migration, data was not received by age as at the end of the mid-year. Instead the inflows and outflows were received by **age as at migration**.
- Therefore although the rates still needed to be calculated as at the start of the mid-year, this couldn't be done in the same way as seen for the death rates and internal migration rates, as the age as at the start of the mid-year is not known.
- Therefore the international migration rates were calculated in a slightly different way to the internal migration rates.

Example 4

- To calculate the 5 year average international ASMigR for inflows of men aged 30 between 2006-07 to 2010-11:

$$ASMigR_{30,m,L} = \frac{\sum_{Y=2006}^{2010} \left(\frac{Inflows_{30,m,L}}{MYE_{30,m,L}} \right)}{5} * 1000$$

Where L= local authority

- However note here that $Inflows_{30,m,L}$ refers to the inflows of men aged 30 **as at migration**. Therefore unlike internal migration where the inflows of men aged 31 as at the end of the mid-year is used, we do not know age as at the start of the mid-year for international migration. Instead we assume age at migration to be the same as the age as at the start of the mid-year.
- This creates a problem when dealing with international migration rates for newborns, because no international migration data is available for Popgroup's definition of 'newborns'. For example, to calculate the international migration rate for people aged 0, international migration inflows/outflows for people aged 0 as at migration are divided by the MYEs of people aged 0 at the start of the mid-year, in a similar calculation as that shown in Example 4. However a rate is also needed for newborns in Popgroup (i.e. people who have not yet been born at the start of the year), but no international migration data is available for newborns at LA level.
- This issue was not a problem in forming rates for newborns for internal migration and mortality, because as explained earlier these data are available by age as at the end of the mid-year, and so to form newborn rates, data for people age 0 as at the end of the mid-year was used as these people would be 'newborn' at the start of the year, i.e not yet born as defined by Popgroup.
- Therefore a rate for newborns needed to be calculated for international migration. It was decided to calculate the international migration rate for newborns as follows:

  $ASMigR_{(newborns)}$ = (1/3)* original $ASMigR_{(age\ 0)}$

  And consequently:

  Final $ASMigR_{(age\ 0)}$ = (2/3)* original $ASMigR_{(age\ 0)}$

  These proportions were taken as these were the international migration rates seen for newborns and 0 year olds in the 2001 Census.

Differentials

Fertility differentials

- These were calculated as:

Births projected in year (ASFR(yr)*pop(yr))/Births expected in year (ASFR(yr)*pop(yr))

This calculation is described in more detail in the examples below.

- Fertility differentials are calculated for women of ages 15-19, 20-24…..45-49. However no ASFRs are available for women of ages 47-49, so the differential for women aged 45-46 is used as a proxy for the 45-49 age group.
- Fertility differentials were calculated from year beginning 1 July 2014 to year beginning 1 July 2038.

- **Note that in the examples below the ASFRs from 2015-16 onwards were derived from the 2013-based national projection for Wales. This is because the differentials were indexed on the projected 2013-14 fertility rates.**
- The population figures were from the 2015-based national projections for Wales.

Example 5

- For year beginning 1 July 2012 for ages 15-19, the differential is as follows:

  [ASFR(15,2012-13)*population(15,2012)+ASFR(16,2012-13)* population(16,2012)+….+ASFR(19,2012-13)*population(19,2012)]/ [ASFR(15,2011-12)*population(15,2012)+….+ASFR(19,2011-12)* population(19,2012)]

Mortality differentials

- These are calculated as:

  Deaths projected in year (ASFR(yr)*pop(yr))/Deaths expected in year (ASFR(yr)*pop(yr))

  This calculation is described in more detail in the examples below.
- Mortality differentials are calculated for ages newborn/0, 1-4…80-81, 85+.
- They are calculated from year beginning 1 July 2015 to year beginning 1 July 2038.
- **Note that in the examples below the ASMRs from 2012-13 onwards were derived from the 2010-based national projection for Wales. This is because the differentials are indexed on projected 2010-11 mortality rates.**
- The population figures were from the 2015-based national projections for Wales.

Example 6

- For year beginning 1 July 2012, for ages 1-4, males, the differentials are computed as:

  [ASMR(m,1,2012-13)*population(m,1,2012)+….+ASMR(m,4,2012-13)*population(m,4,2012)]/ [ASMR(m,1,2011-12)*population(m,1,2012)+….+ASMR(m,4,2011-12)*population(m,4,2012)]

ANNEXE 2: comparison of the projections and the mid-year estimates

This annexe presents a comparison of previous local authority population projections with the mid-year estimates of population published by the Office for National Statistics, to illustrate how accurately the projections have estimated future population change in the past. Population projections are based solely on trends in the most recent years to inform decision making and planning. They do not forecast the impact of future policy changes. Therefore if decisions are made as a result of these projections, or if external factors lead to significant changes in the levels of births, deaths or migration, it would not be unsurprising for levels of population to differ from the projections.

In summary the 2011-based local authority projections have, overall, slightly overestimated population growth from 2011 to 2013 and 2014. This was also true for 15 of the 22 local authorities in Wales. The percentage differences varied from +1.1 per cent for Wrexham to -0.7 per cent for Rhondda Cynon Taf.

Comparisons with the 2008-based projections are not presented here as the publication of the 2011 Census results and subsequent revision to previous population estimates and underlying assumptions mean that comparisons would not be on a consistent or useful basis. For example, the revised mid-year estimate for 2008 was 3,025,867. This is around 26,000 higher than the mid-year estimate used as a base year for the 2008-based local authority projections and any subsequent trends would be significantly different as a result.

2014-based population projections for 2016 and 2016 mid-year estimates, local authorities in Wales

		2014-based population projections					
	2016 mid-year estimate	principal projection	% difference from MYE	lower variant	% difference from MYE	higher variant	% difference from MYE
Isle of Anglesey	69,723	70,170	0.64%	70,129	0.58%	70,195	0.68%
Gwynedd	123,627	122,948	-0.55%	122,883	-0.60%	122,987	-0.52%
Conwy	116,538	116,561	0.02%	116,491	-0.04%	116,600	0.05%
Denbighshire	94,805	95,144	0.36%	95,085	0.30%	95,180	0.40%
Flintshire	154,419	154,372	-0.03%	154,294	-0.08%	154,424	0.00%
Wrexham	136,710	137,927	0.89%	137,851	0.83%	137,977	0.93%
Powys	132,160	132,303	0.11%	132,230	0.05%	132,344	0.14%
Ceredigion	74,146	75,864	2.32%	75,828	2.27%	75,885	2.35%
Pembrokeshire	123,954	123,858	-0.08%	123,790	-0.13%	123,899	-0.04%
Carmarthenshire	185,610	185,485	-0.07%	185,380	-0.12%	185,547	-0.03%
Swansea	244,513	243,046	-0.60%	242,919	-0.65%	243,126	-0.57%
NeathPortTalbot	141,588	140,879	-0.50%	140,802	-0.56%	140,929	-0.47%
Bridgend	143,177	142,038	-0.80%	141,959	-0.85%	142,088	-0.76%
ValeofGlamorgan	128,463	127,985	-0.37%	127,917	-0.43%	128,026	-0.34%
Cardiff	361,468	360,491	-0.27%	360,299	-0.32%	360,619	-0.23%
RhonddaCynonTaf	238,306	237,626	-0.29%	237,492	-0.34%	237,718	-0.25%
MerthyrTydfil	59,810	59,139	-1.12%	59,108	-1.17%	59,162	-1.08%
Caerphilly	180,462	180,481	0.01%	180,384	-0.04%	180,548	0.05%
BlaenauGwent	69,628	69,549	-0.11%	69,510	-0.17%	69,575	-0.08%
Torfaen	92,052	91,799	-0.27%	91,749	-0.33%	91,833	-0.24%
Monmouthshire	92,843	92,639	-0.22%	92,593	-0.27%	92,665	-0.19%
Newport	149,148	147,749	-0.94%	147,666	-0.99%	147,805	-0.90%
Wales	3,113,150	3,108,054	-0.16%	3,106,358	-0.22%	3,109,130	-0.13%

source: StatsWales

The 2014-based principal population projections for 2016 were higher than the 2016 mid-year estimates for 7 of the 22 local authorities in Wales. The percentage differences varied from +2.3 per cent for Ceredigion to -1.1 per cent for Merthyr Tydfil. The lower variants were higher for 5 of the 22 local authorities, and the higher variants were higher for 8 of the 22 local authorities.

2011-based population projections for 2014 and 2014 mid-year estimates, local authorities in Wales

		2011-based population projections					
	2014 mid-year estimate	principal projection	% difference from MYE	lower variant	% difference from MYE	higher variant	% difference from MYE
Isle of Anglesey	70,169	70,075	-0.13%	69,987	-0.26%	70,115	-0.08%
Gwynedd	122,273	122,425	0.12%	122,287	0.01%	122,486	0.17%
Conwy	116,287	115,753	-0.46%	115,620	-0.57%	115,814	-0.41%
Denbighshire	94,791	95,126	0.35%	95,002	0.22%	95,181	0.41%
Flintshire	153,804	153,763	-0.03%	153,582	-0.14%	153,849	0.03%
Wrexham	136,714	138,905	1.60%	138,716	1.46%	138,992	1.67%
Powys	132,675	133,997	1.00%	133,865	0.90%	134,061	1.04%
Ceredigion	75,425	75,764	0.45%	75,691	0.35%	75,799	0.50%
Pembrokeshire	123,666	123,603	-0.05%	123,454	-0.17%	123,670	0.00%
Carmarthenshire	184,898	186,832	1.05%	186,613	0.93%	186,935	1.10%
Swansea	241,297	242,540	0.52%	242,247	0.39%	242,678	0.57%
NeathPortTalbot	140,490	140,543	0.04%	140,360	-0.09%	140,626	0.10%
Bridgend	141,214	141,589	0.27%	141,401	0.13%	141,675	0.33%
ValeofGlamorgan	127,685	128,049	0.29%	127,905	0.17%	128,117	0.34%
Cardiff	354,294	357,982	1.04%	357,479	0.90%	358,221	1.11%
RhonddaCynonTaf	236,888	235,243	-0.69%	234,901	-0.84%	235,391	-0.63%
MerthyrTydfil	59,065	59,567	0.85%	59,479	0.70%	59,604	0.91%
Caerphilly	179,941	180,103	0.09%	179,854	-0.05%	180,212	0.15%
BlaenauGwent	69,674	69,482	-0.28%	69,388	-0.41%	69,522	-0.22%
Torfaen	91,609	91,641	0.03%	91,510	-0.11%	91,698	0.10%
Monmouthshire	92,336	91,836	-0.54%	91,755	-0.63%	91,877	-0.50%
Newport	146,841	148,617	1.21%	148,391	1.06%	148,718	1.28%
TOTAL	3,092,036	3,103,436	0.37%	3,099,487	0.24%	3,105,241	0.43%

source: StatsWales

The 2011-based principal population projections for 2014 were higher than the 2014 mid-year estimates for 15 of the 22 local authorities in Wales. The percentage differences varied from +1.1 per cent for Wrexham to -0.7 per cent for Rhondda Cynon Taf. The lower variants were higher for 12 of the 22 local authorities, and the higher variants were higher for 18 of the 22 local authorities.