Office for National Statistics

Methodology used to produce household projections for England: 2016-based

User guidance about uses, methodology, assumptions and input data for household projections for England.

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1 . Introduction

This article documents the methodology and data used in producing the 2016-based household projections for England. These projections use the 2016-based subnational population projections (SNPPs) published on 24 May 2018.

As with previous household projections, the methodology is split into two stages. Stage 1 produces summary projected household numbers based on trends in population change and household formation and Stage 2 gives a more detailed breakdown of household type. The Stage 1 2016-based household projections were published on 20 September 2018 and the Stage 2 household projections were published on 3 December 2018. This article includes full details about both stages of the methodology. A more accessible high-level overview of the methodology described in this article was published on 27 August 2019. In the future, we intend to publish both stages of the household projections on the same day. This was not possible for the 2016-based household projections, due to the methodological changes applied following the transfer of the household projections from the Ministry of Housing, Communities and Local Government (MHCLG) to the Office for National Statistics (ONS).

Household projections show the number of households[1] there would be in England in the future if a set of assumptions about the size and structure of the population and that population's patterns of household formation were realised in practice. These assumptions are based on past demographic trends in the population and rates of household formation (a list of assumptions made is provided in Section 9).

Household projections are not forecasts and generally take no account of policy or development aims that have not yet had an impact on observed trends. It should also be noted that future demographic behaviour is inherently uncertain, meaning that any set of projections will almost inevitably be proved wrong to some extent, when treated as a forecast or prediction of future numbers of households[2]. Rather, household projections should be thought of as a trend-based starting point for analysis, providing data produced on a consistent basis for England, its regions and local authorities. Further analysis can be taken forward using these data, including the assessment of future housing need.

Household projections for England were previously the responsibility of MHCLG. Previous sets of household projections can be found on the MHCLG website. The ONS took responsibility for the household projections in January 2017. The aim of the transfer was to further improve the consistency between the household projections and the SNPPs and allow us to make some efficiencies in their production. At the same time, we launched a consultation on proposed changes to the household projections methodology, which received 42 responses. We published a response to the consultation in June 2017, setting up a programme of research to look at how the methodology could be improved in light of the feedback we received. This was followed by an article in June 2018, providing an update on our research and the proposed methodology for the 2016-based household projections for England. Section 11 provides a summary of the changes made to the 2016-based household projections methodology, compared with the 2014-based household projections. These changes are also referred to throughout this report.

Household projections are normally published every two years, following the publication of the SNPPs. In the future, we aim to publish the household projections at a similar time to the SNPPs, to provide a more consistent and timely release.

Notes about Introduction

1. The household projections are based on the census definition of a household, which in 2011 was: “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% or more have their own kitchens (irrespective of whether there are other communal facilities) and 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. A household must contain at least one person whose place of usual residence is at the address. A group of short-term residents living together is not classified as a household, and neither is a group of people at an address where only visitors are staying.

2. This inherent uncertainty also applies to population projections that feed into the household projections, as discussed in Fifty years of United Kingdom national population projections: how accurate have they been?. A more recent discussion of the accuracy of national population projections is also available in the National Population Projections Accuracy Report. For a discussion of the accuracy of subnational populations, please refer to the Subnational Population Projections Accuracy Report.

2 . Overview of 2016-based methodology

The methodology for the 2016-based household projections takes the 2014-based methods [1] as its starting point, with changes made considering data availability over time and varying assumptions about household formation and population change. This section provides an overview of the 2016-based methodology. Sections 3 to 7 provide more detail about each part of the method, including the rationale behind the changes made compared with past household projections. For users wishing to carry out their own analysis or modelling, Section 12 provides a list of all the input data sources used in the production of the 2016-based household projections for England.

Like the previous methodology, the 2016-based household projections are compiled using a two-stage process. Stage 1 produces projected total numbers of households by quinary age group and sex of the household reference person (HRP)[2] over the projection period for England, regions and local authorities. The total number of households in each geographical area form the basis of the control totals for Stage 2 of the projection methodology, which gives the detailed household type breakdown.

Stage 1 begins by taking the latest sets of mid-year population estimates (MYEs) and subnational population projections (SNPPs), by quinary age group and sex, and applying an adjustment to remove those living in communal establishments (CEs) using census data. This adjustment uses the same assumptions as the previous methodology. It is also supplemented by administrative data about the prison population. This part of the method produces a projected household population by quinary age group and sex for the years 2001 to 2041.

Like the 2014-based methodology, the 2016-based household projections use household representative rates (HRR), multiplied by the projected household population, to produce projected numbers of households. The HRR is the proportion of people in a particular demographic group (based on geography, age group and sex) who were the HRP. The value of the HRR will be between zero and one. HRRs for 2001 and 2011 are calculated using census data. These HRRs are then projected forward to produce HRRs for the other years of the projection period and applied to the projected household population to produce a projected number of households for 2001 to 2021.

From 2022 to 2041, HRRs are held constant at 2021 rates. Given we are using a 10-year trend in HRRs for projection, limiting the use of this projected trend to a maximum of 10 years into the future mitigates the risks of projecting forward a potentially more uncertain trend for the entire projection period. Household projections are produced separately for England, regions and local authorities. Projected numbers of households for the regions are then constrained to the England total, with figures for local authorities constrained to the relevant regional totals.

Stage 2 begins by calculating household headship rates. Headship rates show the proportion of people in a particular demographic group (based on geography, age group, sex and household type) who were the HRP. The only difference between HRRs and headship rates is that HRRs are calculated by age, sex and geography, and headship rates are calculated by age, sex, household type and geography.

Headship rates are calculated for 2001 and 2011 using census data. These headship rates are then projected forward to produce headship rates for the other years of the projection period and applied to the projected household population to produce an initial projected number of households for 2001 to 2021, with headship rates held constant for 2022 to 2041. The initial projected number of households produced using the headship rates are then constrained to the overall totals by age and sex from Stage 1.

Finally, checks are carried out to ensure that the minimum number of adults and children implied by the projected household type breakdown for each geography and year does not exceed the number of adults and children in the projected household population for that geography and year. Where this is not the case, adjustments are made to the number of households allocated to each household type within that geographical area and year, so that the implied numbers of adults and children are coherent with the projected household population. This process does not affect the overall number of households projected for a given geography and age group, only the household type breakdown within that total.

Sections 3 to 7 provide more detail about each part of the 2016-based household projections methodology, explaining how and why changes have been made compared with the methods used in past household projections.

Notes about Overview of 2016-based methodology

1. The methodology for the 2014-based household projections was based upon the 2012-based, 2011-based interim and 2008-based household projections.

2. In the 2016-based household projections, the household reference person (HRP) is the eldest economically active person in the household. Section 5 provides more information about HRP definitions.

3 . Population estimates and population projections

This section covers the parts of the 2014-based household projections methodology that were outlined in Sections 2a and 2b (pages 7 to 11) of the Household Projections 2014-based: Methodological Report (PDF, 781.7 KB).

Data used

Like the previous method, Stage 1 starts by using mid-year population estimates (MYEs) and subnational population projections (SNPPs) to provide data about the past and projected population of England and its local authorities.

MYEs are for the usual resident[1] population of England as at 30 June each year. They are based on the census and are updated annually to account for population change during the period from 1 July to 30 June. The two main contributors to population change are natural change (births minus deaths) and net migration (the difference between long-term moves into and out of the UK or local areas).

SNPPs are trend-based, making assumptions about future levels of fertility, mortality and migration based on levels observed over a five-year reference period. They are also constrained to the national population projections for England for each year. Therefore, they provide an indication of the possible size and structure of the future population, based on the continuation of recent demographic trends. Population projections are not forecasts and generally take no account of policy or development aims that have not yet had an impact on observed trends.

As well as projecting data for future years, household projections are also produced for past years, to provide a consistent time series[2]. The 2014-based household projections used MYEs data for 1991 to 2014 and 2014-based SNPPs for the years 2015 to 2039[3]. However, MYEs for regions and local authorities for the years mid-2012 to mid-2016 have been revised since the publication of the 2014-based household projections. Therefore, the 2016-based household projections use MYEs data for 2001 to 2016, incorporating estimates from the revised MYE back series, and 2016-based SNPPs for the years 2017 to 2041[4]. The 2016-based household projections provide a shorter time series – 2001 to 2041, as opposed to 1991 to 2039 – because they are using a shorter time series of census data to produce household representative rates (HRR) (see Section 5).

Links to the specific MYEs and SNPPs data used in the 2016-based household projections are provided in Section 12.

Quinary age band changes

MYEs and SNPPs by quinary age band and sex are used for England, regions and local authorities. The quinary age bands used in the 2016-based household projections differ slightly from those used in previous sets of projections. Nine respondents to the consultation on proposed changes to household projections said that the quinary age groups used in the 2014-based method were not appropriate for young adults, students and the elderly population, where they felt there was greater variation in how households were formed. Therefore, in the 2016-based household projections, the 15- to 19-year-old age group has been changed to 16- to 19-year-olds, to better reflect the age at which young adults can be household reference persons (HRPs). The 85 years and over age group has been expanded to two groups: those aged 85 to 89 years and those aged 90 years and over. This change acknowledges the ageing population and provides consistency with the age breakdowns used in the MYEs and SNPPs, which include breakdowns for 85- to 89-year-olds and those aged 90 years and over.

Impact of revised MYEs and rebased SNPPs

The revisions made to the MYEs, rebasing of the population projections from 2014 to 2016 data and changes to the 2016-based SNPPs methodology (compared with that used for the 2014-based SNPPs) all have an impact on the population input data used in the 2016-based household projections.

The revisions made to the MYEs did not affect England-level population estimates by age and sex, but did affect estimates for local authorities. The distribution of people aged in their 20s and 30s changed more than for other age groups, resulting from the use of an updated emigration model and more timely data becoming available to distribute immigration for mid-2015 and mid-2016.

Of all local authorities in England, 92% have revised mid-2016 estimates that are less than 1% different to the original estimates. 200 local authorities (61%) experienced upward revisions and 126 (39%) experienced downward revisions. The population in one local authority was revised upwards by more than 5,000 people (Wandsworth), while four were revised downwards by more than 5,000 people (Cambridge, Haringey, Oxford and Westminster). The population estimates revisions tool enables analysis for specific local authorities.

With regards to the population projections, the overall population of England is projected to be 3.0% lower by 2041 in the 2016-based population projections compared with the 2014-based projections. Table 1 shows that the largest changes are for those aged 0 to 14 years and aged 75 years and over, with 5% fewer people in these age groups by 2041 compared with the previous projections. All age groups have lower projected populations by 2041 compared with the previous projections, except for people aged 60 to 74 years, where the population is projected to be 99,000 higher than under the 2014-based projections. This age group also shows the smallest change between the two sets of projections.

Table 1: Changes in projected population by age between 2014-based and 2016-based population projections, England, selected years

Age group	Mid-2016[1]		Mid-2030		Mid-2041	
	N	%	N	%	N	%
0 to 14	40,874	0.4%	-386,898	-3.7%	-537,530	-5.0%
15 to 29	-33,789	-0.3%	-112,660	-1.0%	-387,624	-3.4%
30 to 44	19,480	0.2%	-325,016	-2.8%	-503,234	-4.4%
45 to 59	24,550	0.2%	93,447	0.9%	-125,586	-1.1%
60 to 74	9,842	0.1%	42,292	0.4%	98,673	1.0%
75 years and over	-11,591	-0.3%	-286,639	-4.3%	-446,861	-5.1%
All ages	49,366	0.1%	-975,474	-1.6%	-1,902,162	-3.0%

Source: Office for National Statistics

Notes:

1. In the 2014-based NPPs and SNPPs, the mid-2016 figures are projections, but in the 2016-based NPPs and SNPPs, the mid-2016 figures are estimates – the starting point of the projection. Therefore, the mid-2016 column of Table 1 compares a projection with an estimate.

2. Figures may not sum due to rounding.

Marital status

The 2014-based household projections also produced Stage 1 totals by marital status [5]. The marital status breakdown has been removed from the 2016-based methodology because the latest available marital status projections, used to produce this breakdown, are the 2008-based, and we have no plans to produce official marital status or relationship status projections in the future. Therefore, we have chosen to remove this breakdown altogether, rather than continue using marital status projections that do not reflect more recent trends in marital and relationship status (particularly results from the 2011 Census).

Notes about Population estimates and population projections

1. The usual resident population includes people who reside, or intend to reside, in the country for at least 12 months, whatever their nationality.

2. Household projections for England, comparisons with other sources: 2001 to 2018 provides an analysis of how household projections for past years compare with household estimates and other sources of household and planning data.

3. It should be noted that the base year of the SNPPs and the MYEs for that year are the same. For example, the mid-2016 population estimates and the population projections for 2016 from the 2016-based SNPPs are the same.

4. The mid-2016 population estimates and 2016-based population projections for 2016 are the same data.

5. The production of marital status composition is described in Section 2b (pages 9 to 11) of Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

4 . Communal establishment and household populations

This section covers the parts of the 2014-based household projections methodology that were outlined in Section 2c (pages 11 to 12) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

Assumptions based on census data

Household projections are based on the household population rather than the total usual resident population. The difference between the two is the population living in communal establishments (CEs) [1]. CEs provide managed residential accommodation, for example, nursing homes, student halls of residence, military barracks and prisons [2].

Therefore, the first step in the methodology is to adjust the mid-year population estimates (MYEs) and subnational population projections (SNPPs) so that they only refer to usual residents living in private households. This adjustment is made by subtracting the population living in CEs from the MYEs and SNPPs. There are currently no sources that can provide consistent and reliable data about the size of the CE population by quinary age and sex for years between censuses. There are administrative data sources that provide information about parts of the CE population; for example, prison population data from the Ministry of Justice. In the future, we will be seeking to make greater use of administrative data in making assumptions about the size of the CE population.

As a result, the primary source used to make assumptions about the size of the CE population is census data. Estimates of the population living in CEs by quinary age group and sex were available from the 2001 [3] and 2011 [4] Censuses at England and local authority level. These estimates are different to those used to calculate the size of the CE population in the 2014-based household projections, as they do not include a marital status breakdown.

The assumption is made that the size of the CE population for the years 2001 to 2010 stays constant at 2001 levels by quinary age group and sex for those aged under 75 years and that the proportion of the CE population stays constant at the 2001 proportion by quinary age group and sex for those aged 75 years and over. The same assumptions are made for the years 2011 to 2041, but using 2011 Census data.

As in the previous method, the distinction between levels and proportions is made on the assumption that an ageing population will lead to greater levels of the population aged 75 years and over living in CEs than would be picked up if 2011 levels were held fixed, but that holding the proportion fixed will account more effectively for population ageing.

The assumptions about levels and proportions are the same in the 2016-based and 2014-based methods, but are applied differently. In the 2014-based method, the population was grouped by age, sex and marital status for the calculations, but in the 2016-based method it is grouped by age and sex only. The change generally has little impact on those aged 0 to 74 years, because the absolute numbers from the census data would be the same when grouped. Males aged 20 to 24 years in Richmondshire were an exception to this pattern.

The 2016-based methodology produced a slightly higher household population than the 2014-based methodology, even when the same unrevised MYEs and 2014-based SNPPs were run through both methods (differences of around 140 people per year from 2011 onwards). It should be noted that Richmondshire has a large armed forces population; according to Ministry of Defence data, there were 6,600 military personnel in Richmondshire in 2016. A high proportion of these would have been young males aged 20- to 24-years-old. The household population results were in line with the census data being used and the differences investigated, but it was not possible to identify why this age-sex group showed larger differences in the 2016-based methods compared with other age-sex groups.

The methods change has more of an impact for those aged 75 years and over, because removing the marital status breakdown changes the numerators and denominators used to apply the proportions, which would have a small impact on the figures for these ages. The results of sensitivity analysis running the unrevised MYEs and 2014-based SNPPs through the 2016-based methodology can be compared with the 2014-based household projections, should users wish to analyse the impact of this change further.

The CE population is subtracted from the total usual resident population in the MYEs and SNPPs by quinary age group and sex to leave the private household population, split by age and sex in the years required for the household projections.

It is possible to make alternative assumptions about the future size and structure of the CE population. For example, we could use proportions or levels from census data for all ages, as opposed to using different assumptions for different age groups. We could also use other sources of administrative data to supplement census data for parts of the CE population, for example, students living in halls of residence.

Links to the census data used in the CE calculations are provided in Section 12.

Prison population adjustments

In previous sets of household projections for England, one-off adjustments have been made to the prison population excluded from the household population for certain groups, using MYEs components of change, to better reflect the growth of the prison population (for example, for young males in the years 2002 to 2008 for the 2008-based household projections[6]).

As a high proportion of change in the prison population is due to legislative change concerning custody, sentence lengths and prison openings and closures, rather than demographic patterns, it was considered impractical to build this into the model for projecting the prison population. However, we have been able to use data about the prison population from the Ministry of Justice to update the number of prisoners in the population for the years 2012 to 2016.

Only prisoners serving sentences of six months or more are enumerated in the census and MYEs at the prison; those serving sentences of less than six months are enumerated at their household. Therefore, we needed to calculate data for the number of prisoners serving sentences of six months or more by age, sex and local authority in England.

To do this, we collated published prison population data from the Ministry of Justice on the number of prisoners in each prison in England by sex for each year from June 2011 to June 2016[7]. Data for individual prisons were then grouped by local authority, to produce numbers of prisoners by sex for each local authority and year. We then collated data on the total number of prisoners by sentence length in England and Wales in June 2011 to June 2016.

Using the age-sex breakdowns provided, we calculated how many prisoners in each year were serving sentences of six months or more. The following categories of prisoner were excluded from the data because they serve sentences of less than six months:

- untried
- convicted unsentenced
- fine defaulter
- less than or equal to six months
- recalls
- sentence length not recorded
- non-criminal prisoners

We calculated what proportion of all prisoners for each age-sex group were serving sentences of less than six months and multiplied this proportion by each local authority's total prison population by sex and year. This amount was subtracted from the original total prison population figure to produce figures adjusted to only include those serving sentences of six months or more.

To produce an age breakdown, we collated data on the total number of prisoners by age and sex in England and Wales in June 2011 to June 2016. These figures were also multiplied by the proportions serving sentences of less than six months and these amounts removed from the totals, to create data for the number of prisoners by age and sex serving sentences of less than six months. The age-sex data were then separated out so they could be reformatted into the quinary age bands used in the household projections.

The age groups 15 to 17 years, 18 to 20 years and 21 to 24 years were divided into single years of age, assuming equal shares of each single year of age in each group. The 25 to 29 years age group was left unchanged, with the remaining age groups from 30 to 39 years to 60 to 69 years divided by two, assuming equal proportions in each quinary age group.

The age group 60 years and over is used in 2011 to 2015, but a 60- to 69-years-old and 70 years and over split is available in 2016. Therefore, we used the proportions of 60- to 69-years-old and 70 years and over in 2016 to split up the 60 years and over age group for the earlier years. We assumed that 60% of the age group 70 years and over were aged 70 to 74 years in all years of the data, due to the smaller numbers of those aged 75 years and over in prisons. We then grouped these data into the quinary age bands used for household projections, as listed in the glossary.

Finally, we divided the number of prisoners in each age group by the total number of prisoners to calculate what proportion of the total number of prisoners should be assigned to each age group. These proportions were applied to the local authority level figures by sex, to produce an age-sex breakdown of prisoners serving sentences of six months or more, by local authority.

There are two main limitations of this approach to age distribution. Firstly, an age distribution for England and Wales is applied to institutions in England only, the inherent assumption being that the overall age distribution of prisoners in England and Wales compared with England alone is broadly similar.

Secondly, the same age distribution is applied to all institutions, even though some institutions will only hold prisoners aged 15 to 21 years (for example, youth justice board and young offenders' institutions). This may have the effect of removing more people aged 21 years and over from the household population than should be removed, although the numbers involved are likely to be relatively small compared with the overall population of a local authority. This is an area of the methodology we will seek to improve upon in future sets of household projections.

The difference between the 2011 prison population and the prison population of the year in question is added to the CE totals from the 2011 Census and this total amount removed from the SNPPs. The size of the prison population for years after 2016 is assumed to be the same as in mid-2016.

While these adjustments have a very small impact at the England level, they provide a more realistic picture of the CE population for local authorities where prisons have opened or closed between the 2011 Census and the base year of the household projections in 2016.

Prison population data are also used in the production of MYEs. A Quality Assurance of Administrative Data report has been produced about prison population data used in the MYEs and will be updated in due course to reflect the use of published prison population data from Offender Management Statistics Quarterly in household projections.

Links to the prison population data used in the CE calculations are provided in Section 12.

Notes about Communal establishment and household populations

1. Previous household projections documentation sometimes referred to the communal establishment population as the “institutional” population – this article uses the term communal establishment (CE) throughout, for consistency.

2. The full definition of a communal establishment can be found in the 2011 Census glossary.

3. For more information, see 2001 Census table CS001, age by sex and resident type.

4. For more information, see 2011 Census table CT0731, sex by age – local authorities in England.

5. See pages 28 to 32, DCLG (2010) Updating DCLG's household projections to a 2008 base: methodology.

6. Immigration Removal Centres (IRCs) were not included in the adjustments, because they hold non-criminal prisoners unlikely to be detained for more than six months.

5 . Household representative rates

This section covers the parts of the 2014-based household projections methodology that were outlined in Sections 2d to 2g (pages 12 to 18) of the Household Projections 2014-based: Methodological Report (PDF, 781.7 KB).

The next stage of the method is to produce household representative rates (HRRs), which can be multiplied by the household population figures to produce a projected number of households. The HRR is the proportion of people in a particular demographic group who were the household reference person (HRP). The value of the HRR will be between zero and one. There have been several changes to the way in which HRRs are calculated for the 2016-based household projections compared with the 2014-based household projections. This section begins by explaining those changes, before explaining the methodology adopted.

Defining the HRP

The HRP is a person chosen for statistical reasons by virtue of economic activity, age and/or sex as the representative of a household. Previous sets of household projections defined the HRP for the Stage 1 household projections as the eldest male within the household, then the eldest female if there was no male, in line with the definition used prior to the 2001 Census. This approach preserved consistency with earlier censuses and enabled data from the 1971, 1981 and 1991 Censuses to be used as part of the process for projecting HRRs. However, previous sets of Stage 2 household projections (broken down by household type) used the 2011 Census definition of HRP; that is, the eldest economically active person in the household, then the eldest inactive person if there was no economically active person[1].

In our response to the consultation on proposed changes to household projections for England, we said we would move to using the standard 2011 Census definition for HRP, as soon as this is consistent with the rest of the projections methodology. This is with a view to improving the transparency of the projections and increasing coherence with other standard population statistics. Therefore, the 2016-based household projections for England use the 2011 Census definition of HRP for both Stage 1 and Stage 2 of the methodology. This also provides internal consistency of definitions within different household projections breakdowns. We have no current plans to change the definition of HRP in the 2021 Census from that which was used in the 2011 Census, so this approach should provide consistency with future census data.

It should be noted that there is a complex routing process to determine which individuals are defined as the HRP. Students at their non-term time address and short-term migrants cannot be defined as the HRP, because they are not considered part of the usual resident population. For households containing a single family, the HRP is the same as the family reference person (FRP)[2]. For other households containing multiple families, unrelated adults and students, the HRP is more complex to identify. For example, in student households, students in full- and then part-time employment take priority over students who are not in employment. In households where all members are retired, the oldest person is defined as the HRP. If there are two people the same age who could be defined as the HRP, the first person listed on the census form is taken to be the HRP.

Consequences of moving to the 2011 Census definition of HRP

Base HRRs are inputted to a model to produce projected HRRs for all years of the projection period. In the 2014-based household projections, base HRRs were calculated for the years 1971, 1981, 1991, 2001 and 2011 using census data. These base HRRs were projected forward using a combination of two fitted trends, combined using assumptions based on Labour Force Survey (LFS) data[3].

Due to the different definition of HRP, only partial information from the 2011 Census was used to produce HRRs in the 2014-based household projections. Complex adjustments were made to the 2011 Census data used to calculate HRRs, to account for the different HRP definitions[4]. Using the 2011 Census HRP definition in the 2016-based household projections removes the need for these adjustments, improving the transparency and accessibility of the methodology.

At the same time, the change of HRP definition means it is no longer possible to use the 1971, 1981 and 1991 Census data used in the previous methodology in the production of the 2016-based household projections. Household data from these censuses used the eldest male definition of HRP, therefore to include data from them in the methodology would require making complex adjustments of a similar nature to the adjustments made to 2011 Census data in the previous methodology.

Our investigations have found that existing tables from the 1991 Census are not available in the required age-sex breakdowns to produce HRRs and we have confirmed that it is no longer possible to commission bespoke tables from these censuses. We would therefore have limited information on which to base such adjustments.

It should also be noted that the Ministry of Housing, Communities and Local Government (MHCLG) expressed concerns about the 1991 Census data used in previous sets of household projections, stating that, “there remain issues that some of the Census points (particularly the 1991 Census) look to be quite strange.”[5]

As a result of these considerations, we have not included data from the 1971, 1981 or 1991 Censuses in the production of 2016-based household projections for England. The 2016-based household projections use base HRRs calculated using 2001 and 2011 Censuses only.

In the consultation on proposed changes to household projections for England, a total of 15 respondents considered using data from only two censuses to be insufficient. There was a view that only using the 2001 and 2011 Censuses would result in a downward trend in household formation for the younger age groups, which in turn would downplay the need for housing for younger people. With these views in mind, Section 8 shows the results of sensitivity analysis in which 2014-based HRRs (projected using 1971 to 2011 Census data) are applied to the 2016-based subnational population projections (SNPPs), should users wish to investigate the impact of the change of HRR methodology on the household projections.

Demographic breakdowns of HRRs

The Stage 1 2014-based household projections calculated HRRs by age group, sex and marital status for each geography. As outlined in Section 3, the marital status breakdown has been removed from the 2016-based methodology because the latest available marital status projections, used to produce this breakdown, are the 2008-based, and we have no plans to produce official marital status or relationship status projections in the future. Therefore, we have chosen to remove this breakdown altogether, rather than continue using marital status projections that do not reflect more recent trends in marital and relationship status (particularly results from the 2011 Census).

Calculating base HRRs using 2001 and 2011 Census data

As a result of these changes, base HRRs for the 2016-based household projections are calculated using 2001 and 2011 Census data. For each age group, sex, area and year (2001 or 2011), the number of HRPs is divided by the household population (those who could be a HRP), to produce the HRR. It should be noted that the household population used is taken from the relevant Census, as opposed to the mid-year population estimate (MYE) for 2001 or 2011. This is to account for the difference in reference date of the Censuses and MYEs [7].

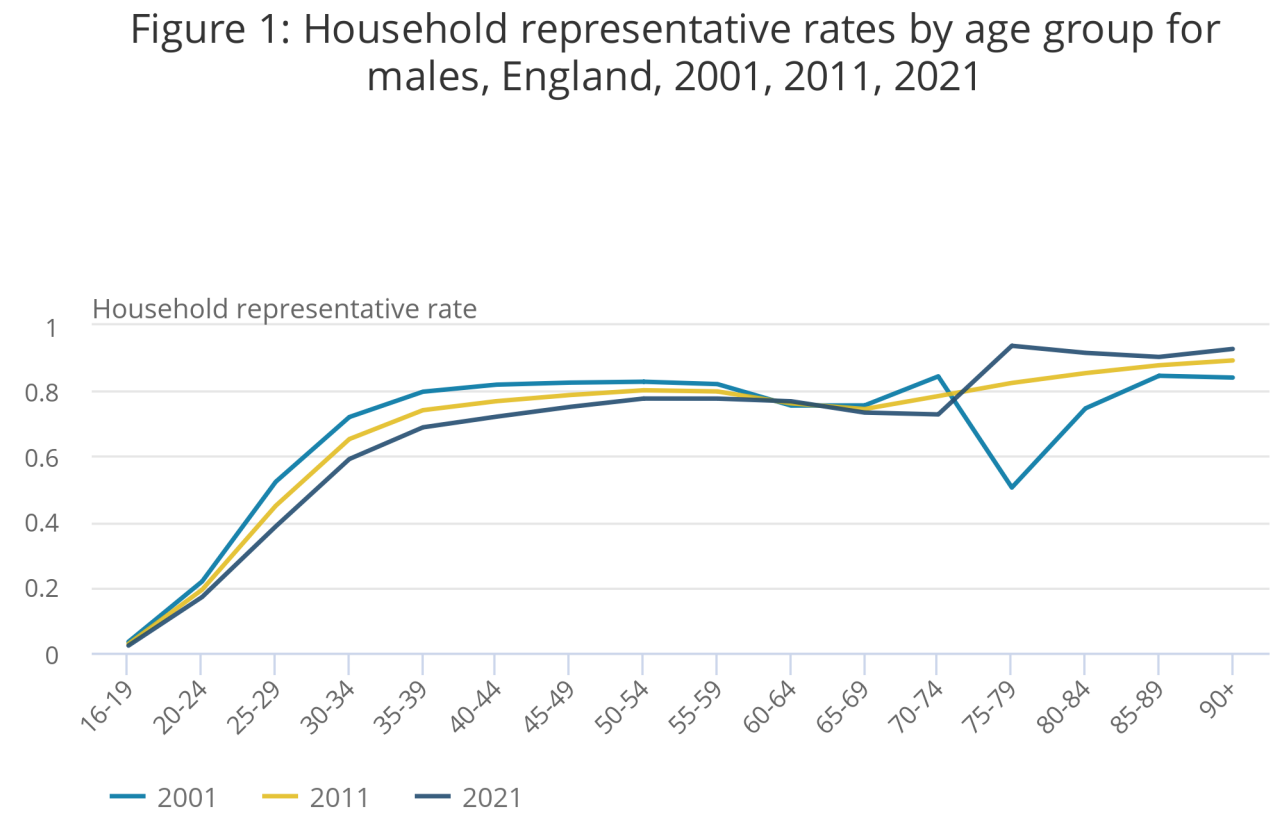
HRRs are calculated for merged local authorities in England. This means that HRRs for the City of London and Westminster, and for Cornwall and the Isles of Scilly, are calculated jointly. This results in 324 sets of HRRs by age and sex for local authorities, as opposed to 326. The HRRs are calculated jointly because 2001 and 2011 Census data for the number of HRPs by quinary age group and sex in the City of London and the Isles of Scilly are disclosive and not able to be published. In addition, HRRs broken down by quinary age group and sex for these smaller local authorities would be based on relatively small populations and would be more susceptible to large changes between 2001 and 2011, that may not be a reflection of overall patterns of household formation.

Links to the census data used to calculate HRRs are provided in Section 12.

Smoothing base HRRs

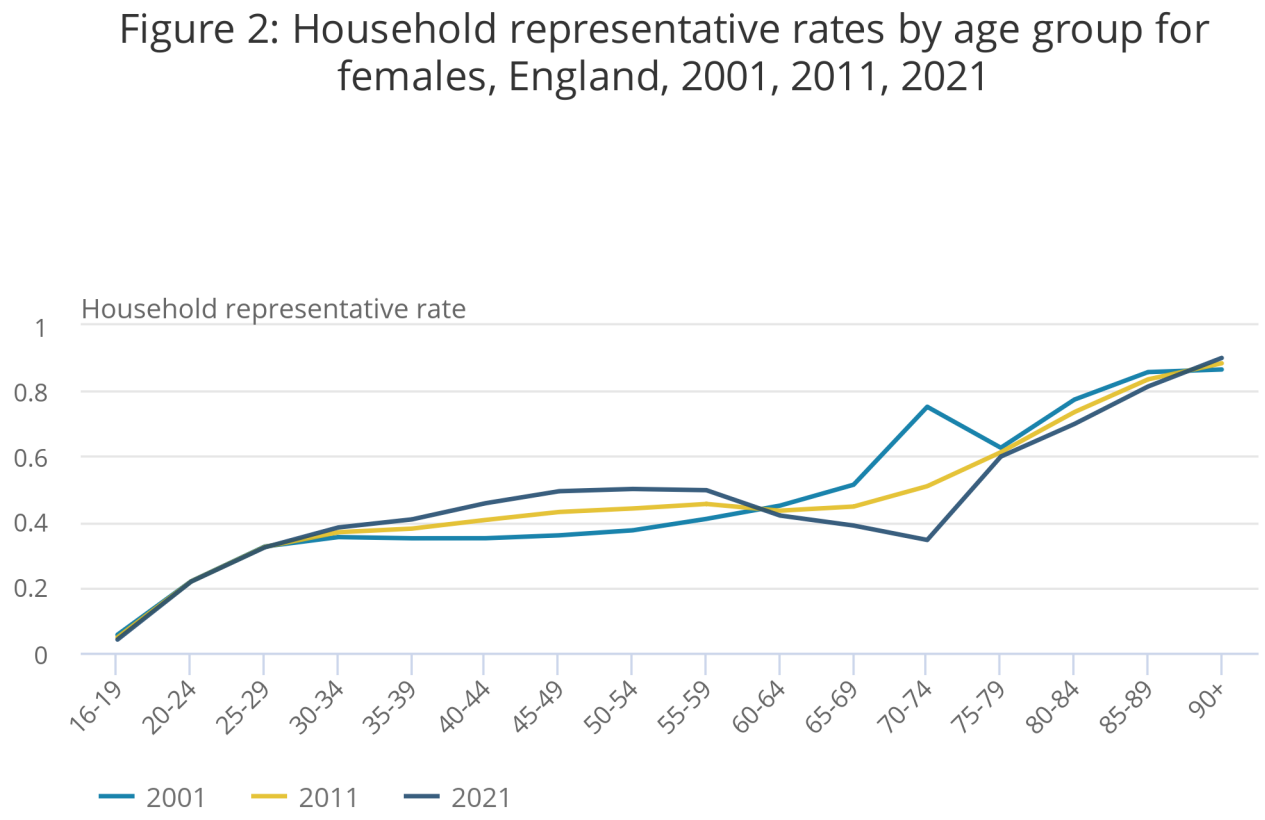
Our research identified that the base HRRs calculated using 2001 Census data showed unusual trends for 75- to 79-year-old males and 70- to 74-year-old females when they were compared with HRRs for similar age groups, as shown in Figures 1 and 2 respectively. These trends were not apparent in 2011 Census data, but were affecting the projected HRRs for 2021.

Figure 1: Household representative rates by age group for males, England, 2001, 2011, 2021



Source: Office for National Statistics

Figure 2: Household representative rates by age group for females, England, 2001, 2011, 2021



Source: Office for National Statistics

We identified that these discrepancies were likely to be a cohort effect, relating to changes in retirement patterns and the impact of World War Two, which may have changed the relative size and structure of these cohorts and therefore their likelihood of being HRPs.

The overall impact on numbers of households in each geographical area was relatively small, because the lower HRRs for males and higher HRRs for females somewhat compensated each other. However, the breakdown of households by age and sex of HRP was affected. This in turn could affect the household type breakdowns produced in Stage 2.

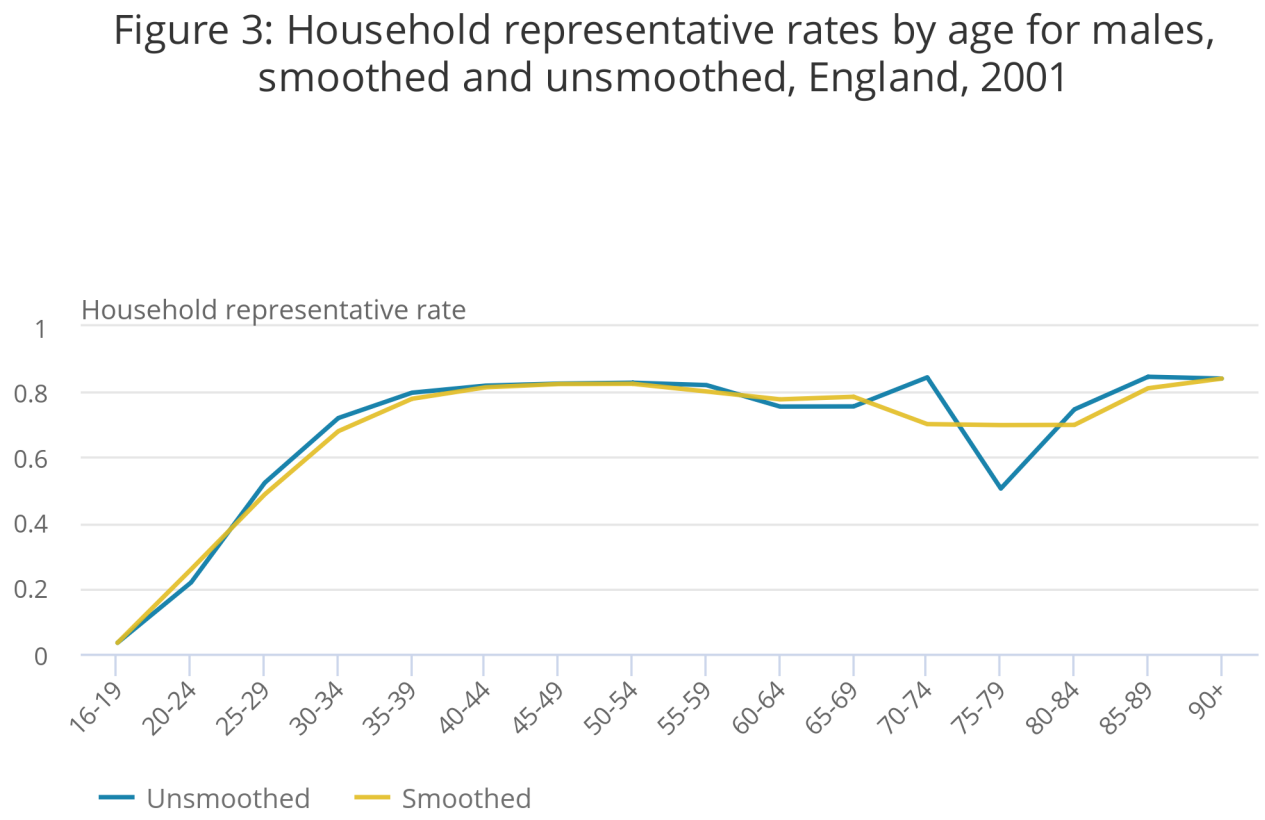
Not wanting a cohort effect to impact projected HRRs for older age groups, we made the decision to smooth the base HRRs produced from 2001 and 2011 Census data across age groups for males and females, to reduce the impact of the apparent cohort effect and produce a more plausible set of HRRs and projected households when broken down by age and sex of HRP. This is the only change made to the methodology since the publication of 2016-based household projections for England: changes to methodology in June 2018.

Smoothing method

The HRRs for 2001 and for 2011 were smoothed using a three-point moving average; for example, the HRRs for 20- to 24-year-olds in the smoothed method are an average of the HRRs for 16- to 19-year-olds, 20- to 24-year-olds and 25- to 29-year-olds. The HRRs for those aged 16 to 19 years and aged 90 years and over (the start and end of the age range) have not been smoothed. This is because the HRRs for 16- to 19-year-olds are considerably lower than those for 20- to 24-year-olds, so only averaging those two age groups created HRRs that were much higher than the unsmoothed HRRs. When multiplied by the household population, this approach added up to 200,000 households headed by 16- to 19-year-olds to the projections in a given year. Given that most 16- to 18-year-olds are likely to remain in education in the future and are therefore perhaps more likely to remain living with their parents, this result seemed implausible.

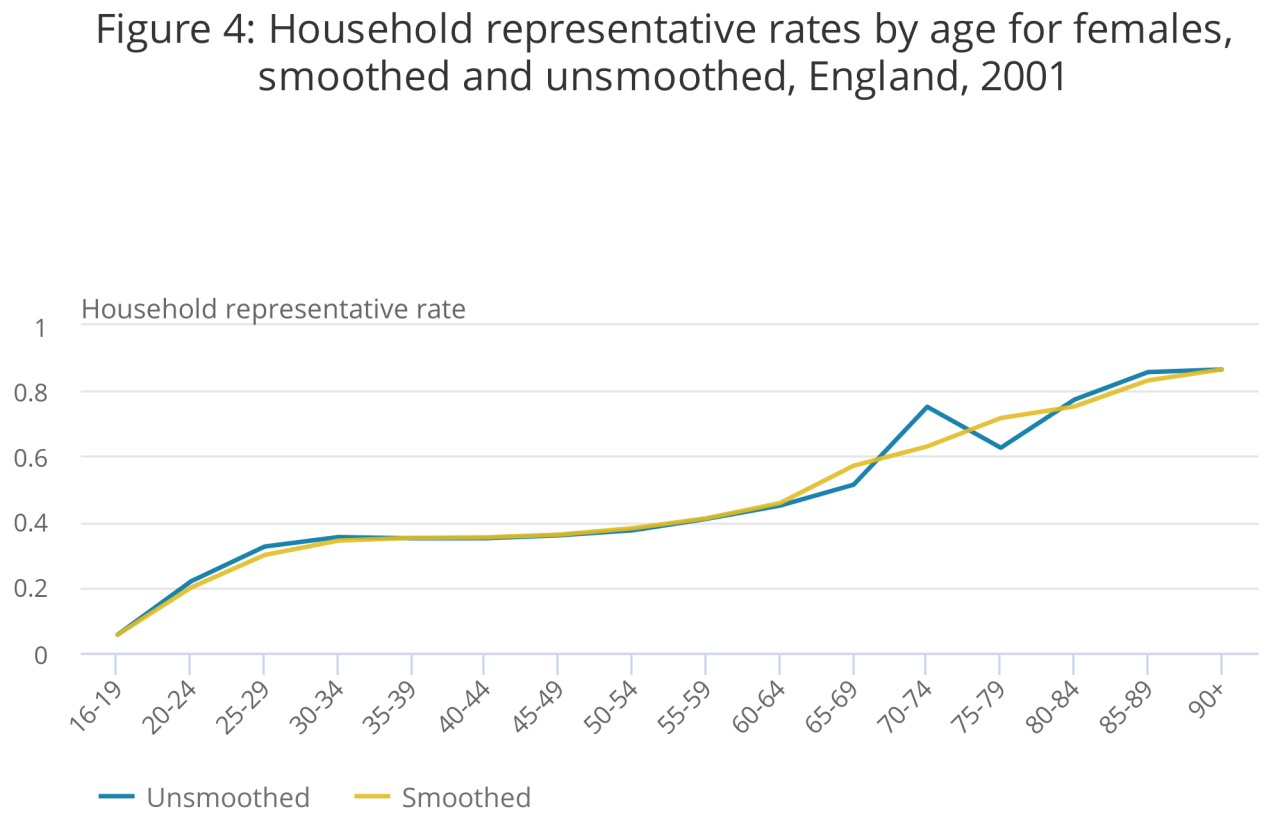
There was less impact at the other end of the age range, on HRRs for those aged 90 years and over, because the HRRs for this age group in 2001 and 2011 were quite similar to those for the 85- to 89-year-old age group. However, for consistency, the HRRs for both 16- to 19-year-olds and those aged 90 years and over have not been smoothed. Figures 3 and 4 show how the smoothing increases the HRRs for 75- to 79-year-old males and reduces them for 70- to 74-year-old females in 2001.

Figure 3: Household representative rates by age for males, smoothed and unsmoothed, England, 2001



Source: Office for National Statistics

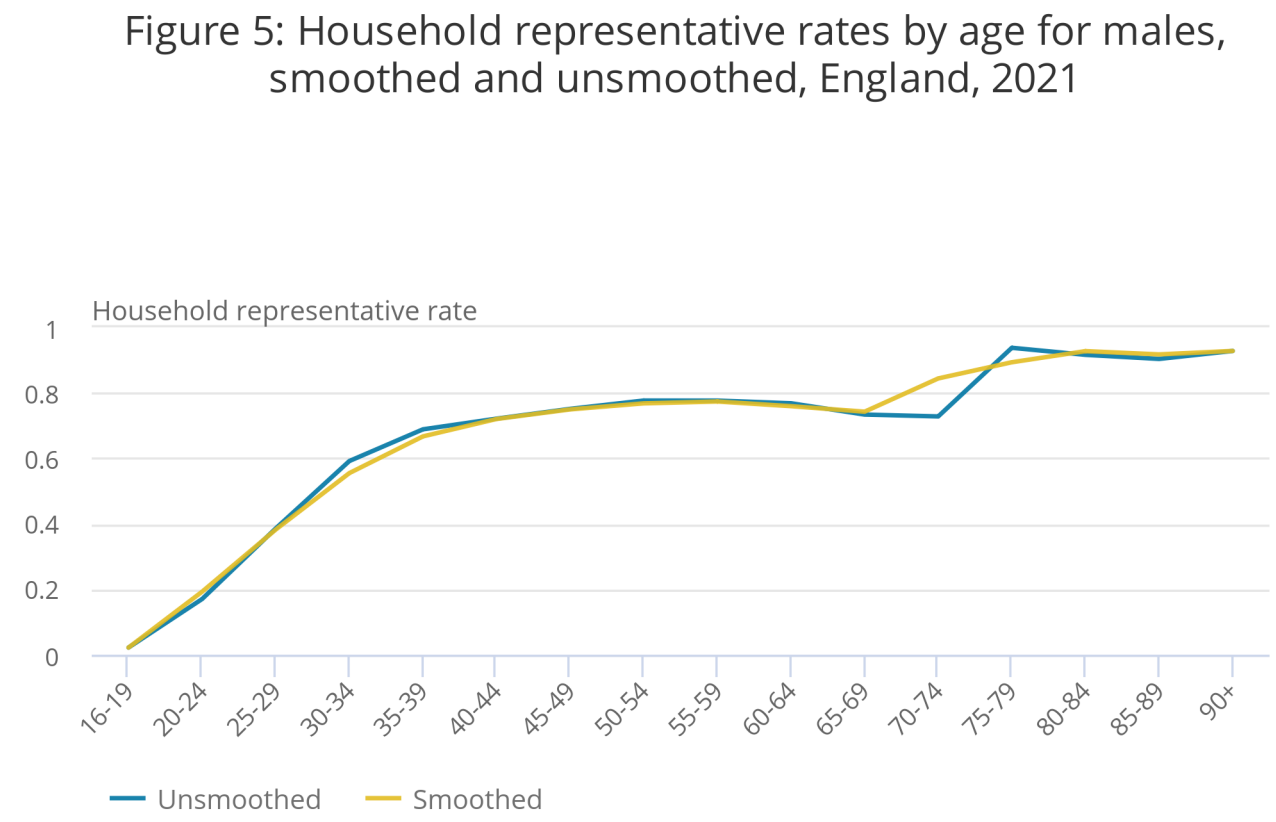
Figure 4: Household representative rates by age for females, smoothed and unsmoothed, England, 2001



Source: Office for National Statistics

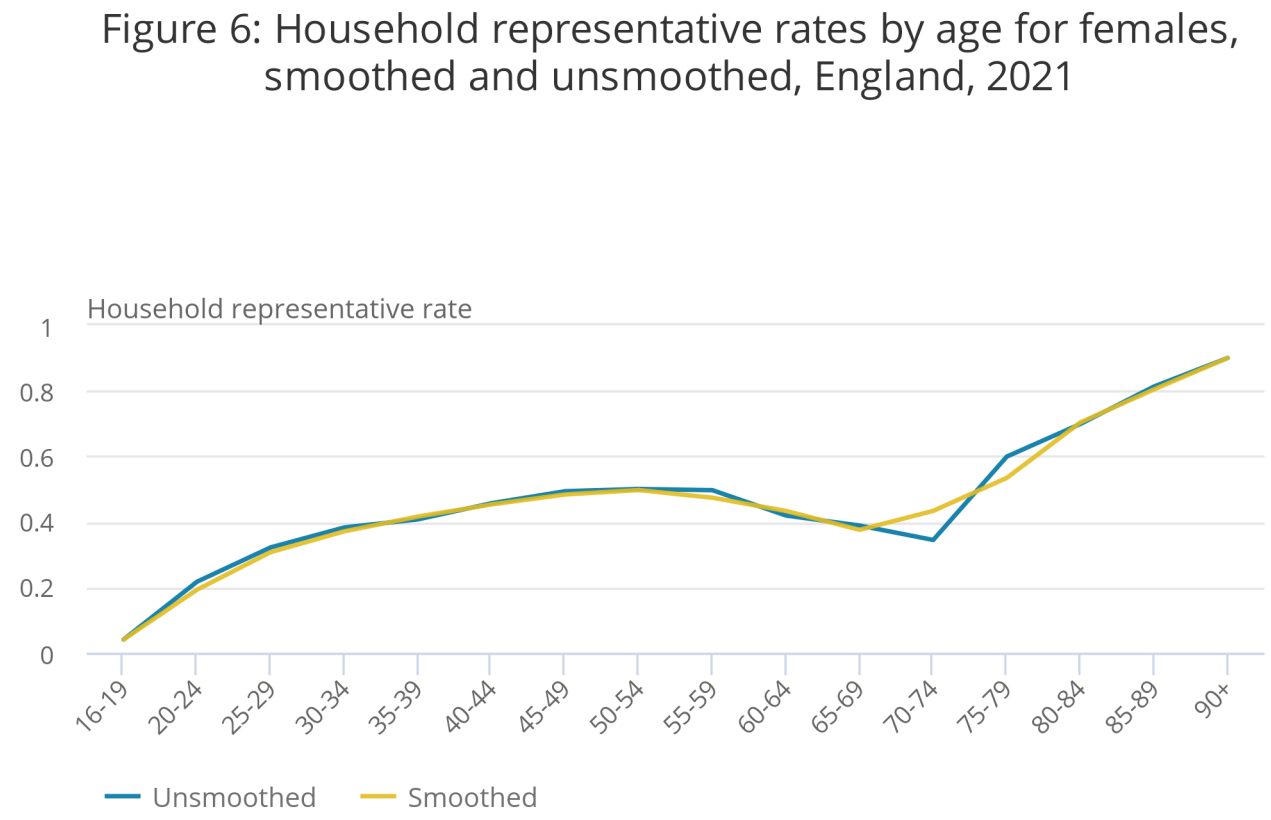
Figures 5 and 6 show how increases in HRRs for older ages in the projected trends for 2021 are more gradual across the age groups in the smoothed HRRs, compared with the unsmoothed.

Figure 5: Household representative rates by age for males, smoothed and unsmoothed, England, 2021



Source: Office for National Statistics

Figure 6: Household representative rates by age for females, smoothed and unsmoothed, England, 2021



Source: Office for National Statistics

Projecting base HRRs forward

Once smoothed, the base HRRs for 2001 and 2011 are projected forward to produce HRRs for the other years of the projection period.

In the 2014-based household projections, the base HRRs (for 1971 to 2011) were projected forward using a combination of two fitted trends, the results of which were combined using assumptions based on LFS data [8]. Because of the changes to how base HRRs are calculated, we have also changed the methodology used for projecting forward HRRs.

The 2016-based household projections use a two-point exponential model [9] to project forward HRR calculated using 2001 and 2011 Census data for each demographic group. The formula for projecting forward base HRRs is as follows:

$y_i = k + ab^{x_i}$

Where:

- i is the year, from 2001 to 2041
- y_i is the headship rate in year i
- c is the most recent census year (2011)
- d is the furthest away census year (2001)
- k is 1 if $y_c >= y_d$ and k is 0 if $y_c < y_d$
- a is y_d minus k
- b is $(y_c – K) / (y_d – k)$
- x_i is $(i – d) / (c – d)$

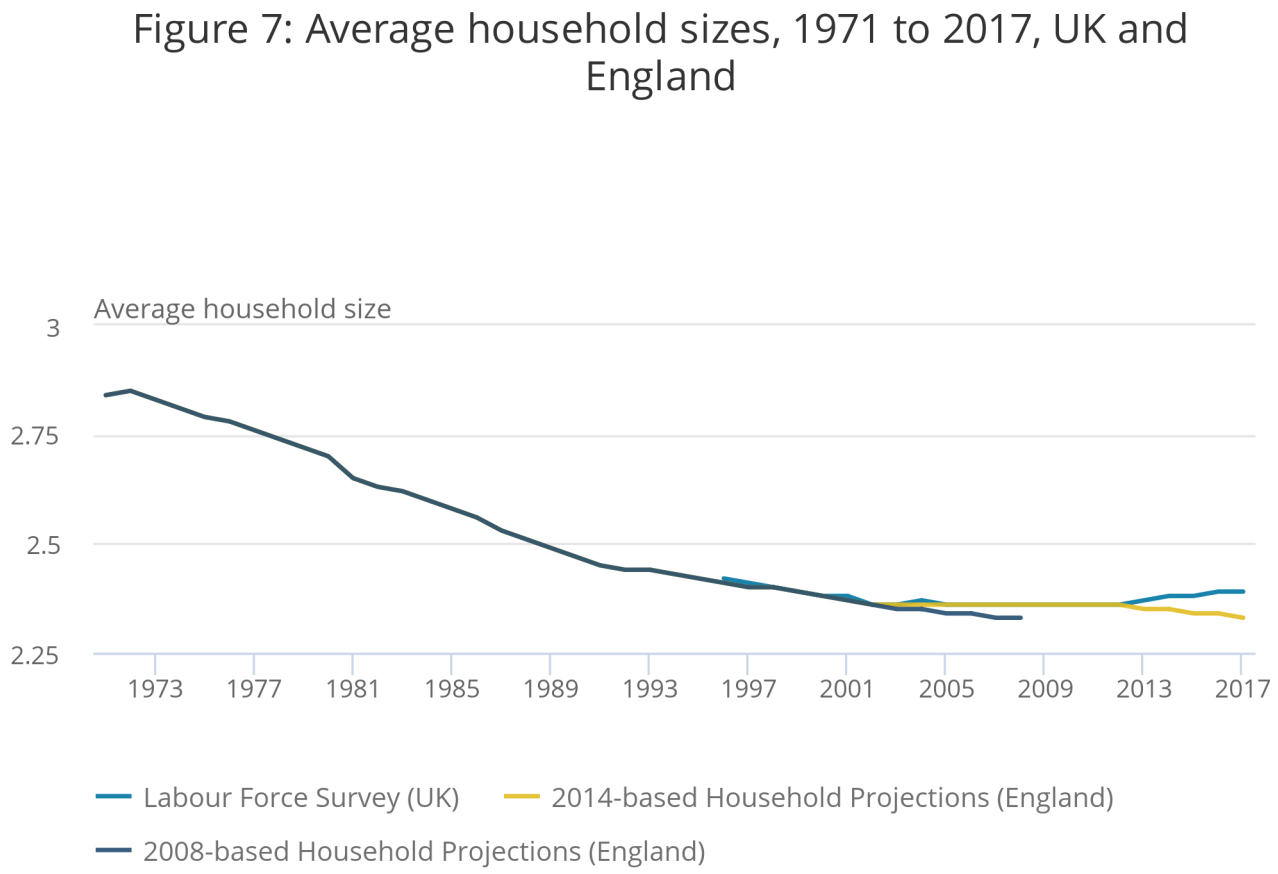
The values of c and d are constants; that is, for each year of the projection period, c will equal 2011 and d will equal 2001.

HRRs calculated using 2001 and 2011 Census data for each demographic group are projected forward using this formula through to 2021. From 2022 to 2041, HRRs by age, sex and geography are held constant at 2021 rates. The following part of this section explains the rationale for this approach.

There is general acknowledgement that between 1971 and 2001, average household size declined and household formation increased[10]. Between 2001 and 2011, these trends slowed down; average household size remained broadly the same and household formation did not increase as much (or even declined for some age groups).

Figure 7 shows that the 2008-based household projections (produced prior to the 2011 Census) projected that average household size would continue to decline into the 2000s, whereas the 2014-based household projections (produced following the 2011 Census) projected stable average household sizes throughout the 2000s. UK average household sizes as observed in the LFS matched the 2014-based household projections until 2011, since which average household sizes have been increasing.

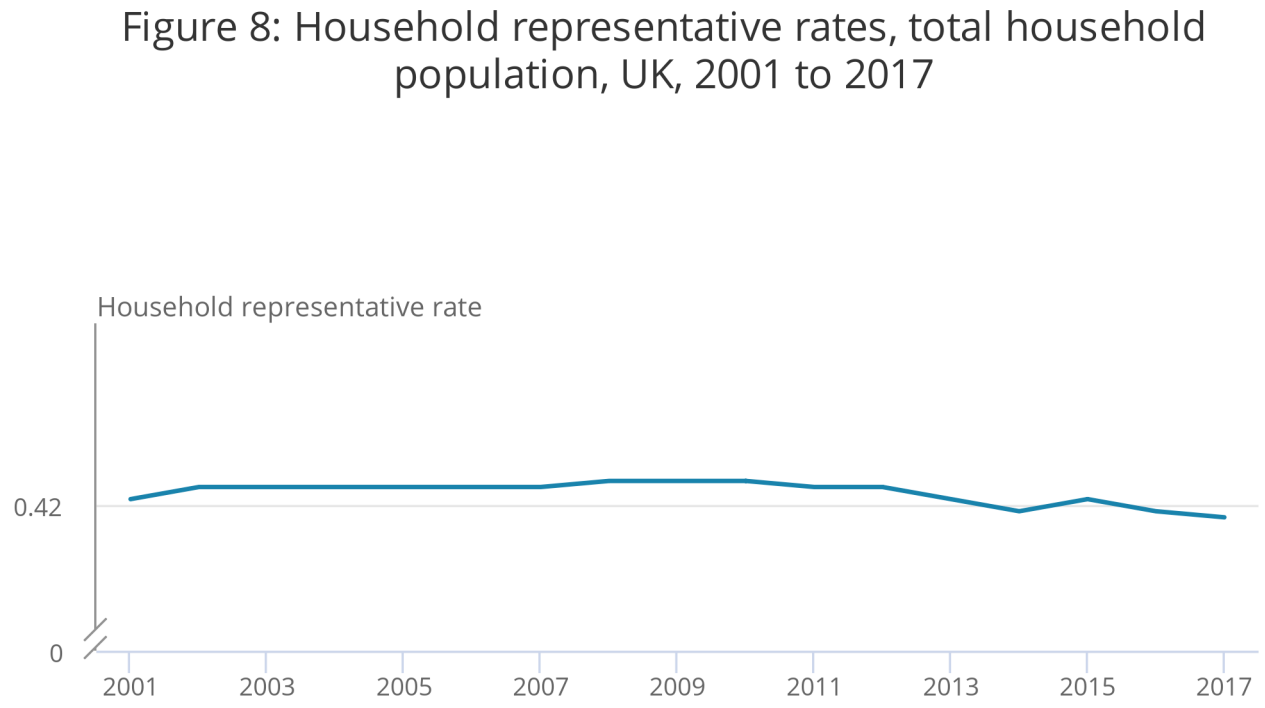
Figure 7: Average household sizes, 1971 to 2017, UK and England



Source: Office for National Statistics

It is unclear whether the trends seen between 2001 and 2011 were a blip in the long-term trend (this being an unusual decade due to EU Accession and the financial crisis), or the start of a longer-term trend. Figure 8 shows that at the UK level, HRRs have declined slightly since 2011, having been broadly level between 2001 and 2011. This evidence of observed trends to 2017 adds validity to the approach of projecting HRRs forward 10 years from 2011 to 2021.

Figure 8: Household representative rates, total household population, UK, 2001 to 2017



Source: Office for National Statistics

We also know that the 2001 to 2011 trends represent actual changes occurring over a 10-year period. Given we are using a shorter trend for projecting HRRs due to the changing HRP definition, limiting the use of this projected trend to a maximum of 10 years forward mitigates the risks of projecting forward a potentially more uncertain trend for the entire projection period. Therefore, the 2016-based household projections method assumes that these trends continue for a maximum of another 10 years (that is, from 2011 to 2021).

As trends become less certain after 2021 and beyond the 10-year point, HRRs are then held constant at the level they are at in 2021 for the rest of the projection period. This is similar to the approach used in national population projections (NPPs) for net migration assumptions; they vary based on past data for the initial part of the projection period, but are then held constant at 165,000 to the UK every year from 2022 to 2023 onwards in the principal UK NPPs[11]. This approach avoids projecting forward changes seen in a short trend (which may not be reflective of longer-term trends in household formation) for the entire projection period, while also avoiding using HRRs based on older censuses, which are unlikely to reflect more recent trends in household formation.

Use of other data sources in the projection of HRRs

The 2014-based household projections used LFS data in the projection of HRRs, to adjust the 2011 Census data point to reflect the new HRP definition, to combine the two fitted trends used to project forward the five census points of data and to make further adjustments at the England level for 2002 to 2011 data.

We have decided not to incorporate the LFS or any other data sources into the projection of the HRRs for Stage 1 of the 2016-based household projections, primarily to reduce the complexity of the method. As we are no longer using the eldest male definition of HRP, we no longer need to use the LFS to adjust the 2011 Census data to refer to this definition. As we are using only two census points and a different projection model, we no longer need to use the LFS to combine the two fitted trends in the previous model. The assumption about projecting HRRs for 2011 to 2021 has been informed by analysis of HRRs from LFS data, although neither the LFS nor any other data sources have been incorporated in to the model itself.

In the future, we intend to carry out further research about how other data sources (particularly administrative data sources) might be used to provide more recent trends for projecting HRRs.

Notes about Household representative rates

1. The full explanation of the current HRP definition can be found on page 23 of the 2011 Census Glossary.

2. The family reference person (FRP) is identified by criteria based on the family make-up. In a lone parent family, it is taken to be the lone parent. In a couple family, the FRP is chosen from the two people in the couple on the basis of their economic activity (in the priority order: full-time job, part-time job, unemployed, retired, other). If both people have the same economic activity, the FRP is identified as the elder of the two or, if they are the same age, the first member of the couple on the form.

3. This process is outlined in Sections 2f and 2g (pages 16 to 18) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

4. These adjustments are outlined in Section 2e (pages 13 to 16) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

5. These issues are described in Section 2f (pages 16 to 17) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

6. The reference date for the 2001 Census is 29 April. The reference date for the 2011 Census is 27 March. The reference date for the mid-year population estimates (MYEs) is 30 June.

7. These issues are described in Section 2f (pages 16 to 17) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

8. This model is also used by National Records of Scotland in the production of Household Projections for Scotland (2016-based) (4.63MB) – see page 62.

9. For more information, see Berrington A and Simpson L (2016), ‘Household Composition and Housing Need’ in: Champion T and Falkingham J (eds.), Population Change in the United Kingdom, Rowman and Littlefield, pages 105 to 124.

10. For more information please refer to the Migration Assumptions section of the National population projections: 2016-based projections, methodology.

6 . Numbers of households and geographical constraining

This section covers the parts of the 2014-based household projections methodology that were outlined in Section 2h (pages 18 to 19) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

The 2014-based Stage 1 household projections model used a top-down approach, producing household projections for England, then regions and then local authority districts. The 2016-based Stage 1 methodology takes a similar approach, in that household projections are calculated separately for England, regions and local authority districts. However, in the 2014-based household projections, different methods were used to produce household representative rates (HRRs) at the England level, compared with at the regional and local authority level. This was due to the use of LFS data to adjust the 2011 Census point and 2002 to 2011 data at the England level, which was not then possible to repeat for regions or local authorities due to the sample size of the LFS [1].

The 2016-based household projections apply the same methodology for producing HRRs to England, regions and local authorities, using 2001 and 2011 Census data for all three geographical levels, as outlined in Section 5. Therefore, we have not applied geographical constraining to the HRRs. Once HRRs have been produced for all years of the projection period, broken down by age, sex and geographical area, they are multiplied by the corresponding household population for each age, sex, geographical area and year to produce a projected number of households for 2001 to 2041.

The HRRs for the merged local authorities (City of London and Westminster, Isles of Scilly and Cornwall) are multiplied by the household populations for the unmerged local authorities, to produce unmerged projected numbers of households for the four local authorities separately.

Although the HRRs for the 2016-based Stage 1 household projections have not been geographically constrained, we have retained an element of geographical constraining. Once projected numbers of households have been calculated for England, regions and local authorities, the regional numbers of households are constrained to the England total and local authority level numbers of households are constrained to the regional totals. This constraining takes place on the assumption that England and regional level projections will be less subject to variation due to smaller populations than household projections for local authorities. This approach also provides consistency across geographies.

It should be noted, therefore, that the HRRs presented in the detailed data for modelling and analysis reflect household formation patterns prior to geographical constraining. It is possible to produce HRRs that reflect the impact of geographical constraining by dividing the overall number of households for a given area, age-sex group and year by the household population for the same area, age-sex group and year.

Notes about Number of households and geographical constraining

1. These methods are outlined in Section 2h (pages 18 to 19) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

7 . Household type breakdowns (Stage 2 methodology)

This section covers the parts of the 2014-based household projections methodology that were outlined in Section 3 (pages 20 to 23) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB).

Calculating household headship rates

As in previous sets of household projections, Stage 2 2016-based household projections provide projected numbers of households by household type and age.

Stage 2 begins by calculating base household headship rates. Headship rates show the proportion of people in a particular demographic group (based on geography, quinary age group, sex and household type) who were the household reference person (HRP). The only difference between household representative rates (HRRs) and headship rates is that HRRs are calculated by age, sex and geography, and headship rates are calculated by age, sex, household type and geography. The same age groups are used to calculate HRRs in Stage 1 and headship rates in Stage 2.

As in Stage 2 of the 2014-based household projections and Stage 1 of the 2016-based household projections, headship rates are calculated using 2001 and 2011 Census data, based on the current definition of HRP – the oldest economically active person in the household. The base headship rates for 2001 and 2011 for each geography, sex and household type were smoothed over the age distribution using the same three-point moving average as used in Stage 1, with HRRs for those aged 16 to 19 years and 90 years and over left unsmoothed. Headship rates are calculated separately for males and females because they are smoothed across age groups (maintaining consistency with the Stage 1 HRRs) and males and females have different distributions of headship rates. The initial Stage 2 projected household totals are then constrained to the Stage 1 projections by age, sex and geography.

These smoothed headship rates are then projected forward using the same two-point exponential model as used in Stage 1, to produce projected headship rates for the years 2001 to 2021. As in Stage 1, headship rates for 2022 to 2041 are held constant at 2021 rates.

Stage 2 household types

The household types used in past sets of household projections differ from those used in standard 2011 Census outputs. Commissioned census tables were used to provide the best comparable information from the 1991 and 2001 Censuses to produce past sets of household projections. Commissioned census tables from the 2001 Census (table C1092_01) and 2011 Census (table CT0691) have also been used in the production of the 2016-based household projections. Table CT0691 was used instead of table BD0105 to provide 2011 Census data, as it can be made publicly available for users to analyse as part of further research.

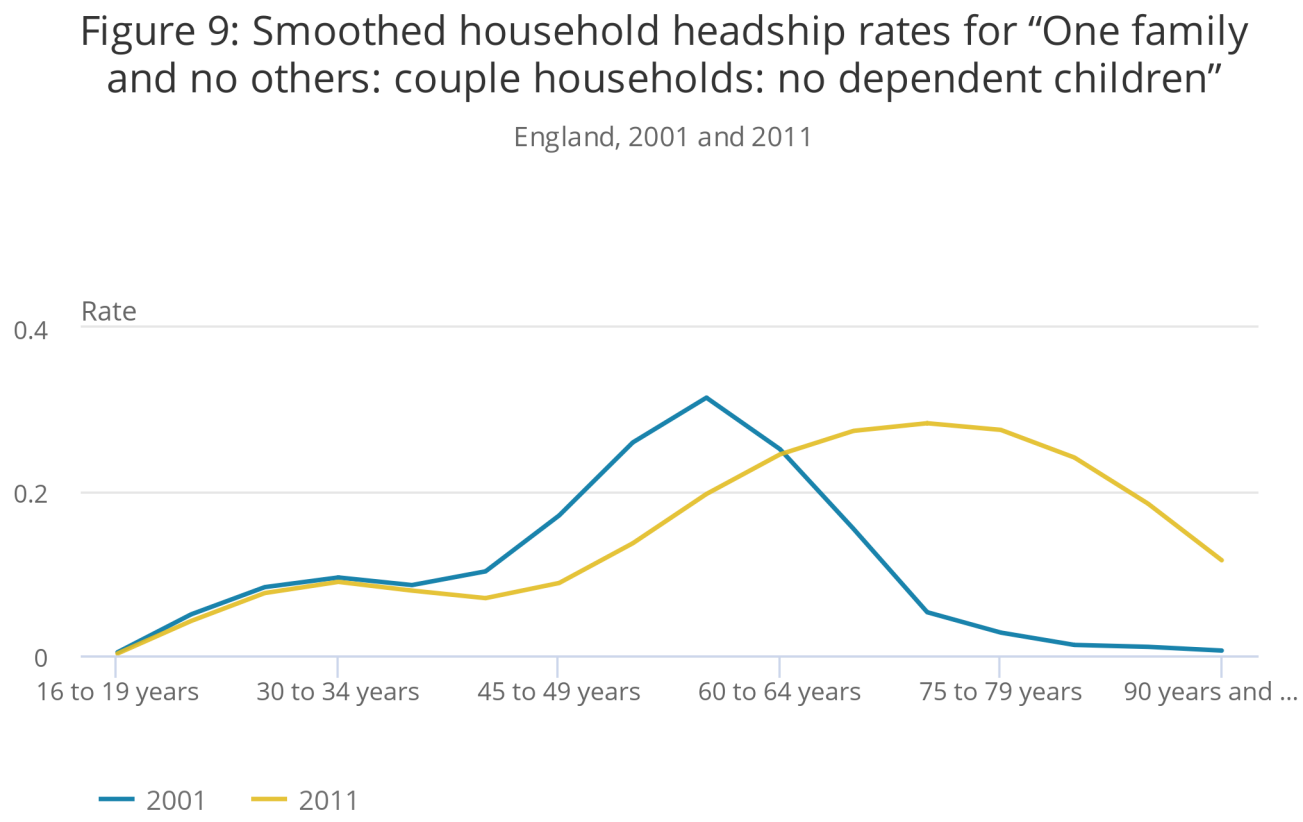
Past sets of Stage 2 household projections used a “17 type” aggregation of households. This was not possible for the 2012-based and 2014-based household projections, since the calculation of household type classification (which differs from the standard Census outputs classification) cannot be applied to the 2011 Census in a way that is consistent with the 2001 Census for all household types. A simplified “8 type” classification was used, as it was considered the best for projecting trends, given the data available.

As part of our June 2018 update on the proposed methodology for the 2016-based household projections for England, we asked users for feedback about the household types used in Stage 2 of the household projections. This feedback and further consultation with members of the Household Projections Collaborative Group showed that no single household type breakdown is likely to meet the needs of all users, with mixed responses about the benefits and costs of moving to a new set of household types at this time. Therefore, we made the decision to maintain as much consistency as possible with the previous sets of household projections for the 2016-based round. In the future, we are intending to carry out further research into what type breakdowns are the most feasible and helpful for users, with a view to updating the breakdowns used for the next set of household projections.

Therefore, we carried out analysis to implement Stage 2 of the household projections using the “8 type” household categorisation. However, as shown in Figures 9 and 10, this analysis identified unusual patterns in the smoothed base headship rates for two of the eight categories, calculated using 2001 and 2011 Census data from tables C1092_01 and CT0691.

Figure 9: Smoothed household headship rates for “One family and no others: couple households: no dependent children”

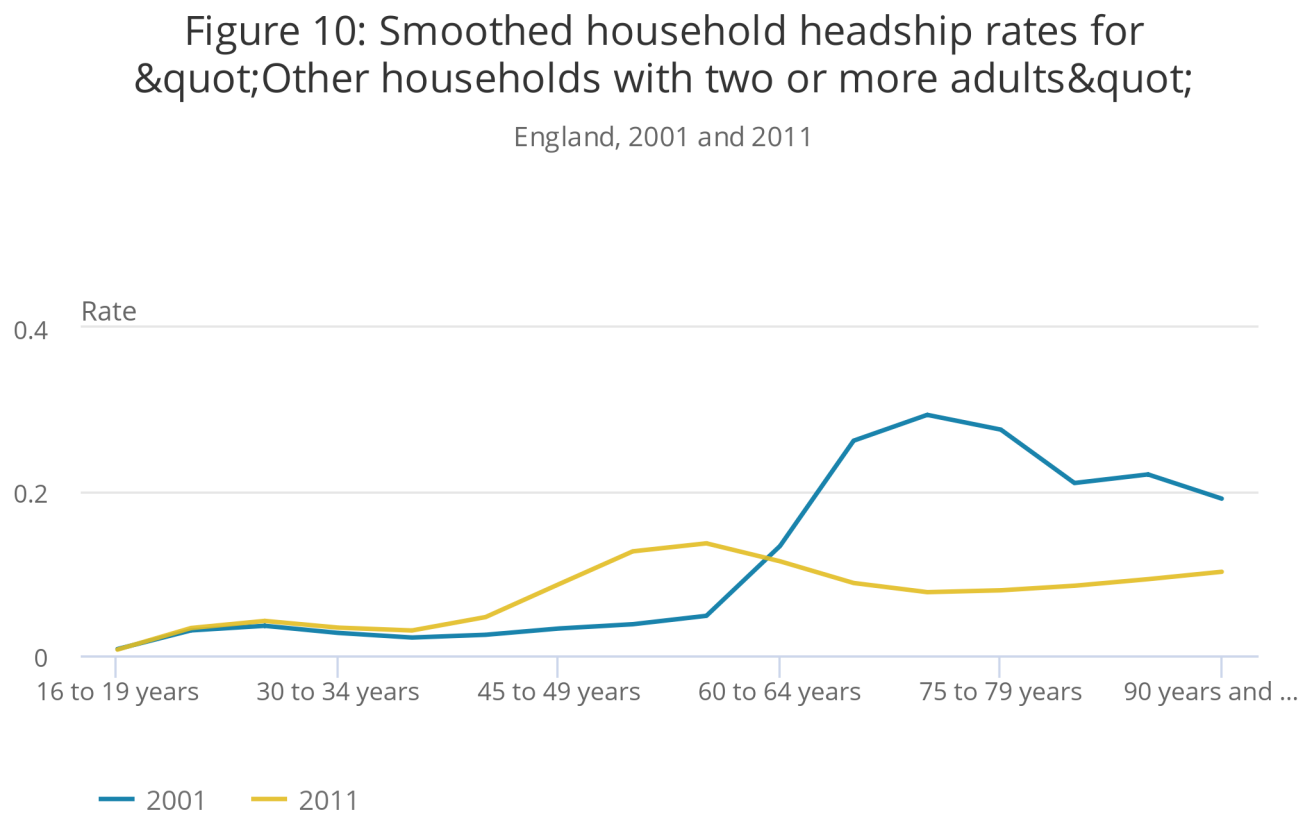
England, 2001 and 2011



Source: Office for National Statistics

Figure 10: Smoothed household headship rates for "Other households with two or more adults"

England, 2001 and 2011



Source: Office for National Statistics

Figure 9 shows a steady decline in the headship rates for the category “One family and no others: couple households: no dependent children” between the ages of 55 to 59 years and 70 to 74 years, with a more gradual decline for the remaining older age groups. In contrast, Figure 10 shows a steady increase in the headship rates for “Other households with two or more adults” over the same age range, with a more gradual decline for the subsequent older age groups. These trends are not reflected in 2011 Census data and, if these differences were projected forward, would result in notable changes in household type trends. The low headship rates for older couple households seem implausible given that many households headed by older people are likely to be either single person or couple households.

It is not absolutely clear what is driving the differences between these two categories. We explored whether grouping household type categories from the 2001 Census data in different combinations would resolve the issue, but discrepancies remained. Other possible explanations include whether changes to couple categorisations between the 2001 and 2011 Censuses had an effect (for example, the inclusion of same-sex civil partnership couples in 2011), whether increasing rates of separation and divorce had an impact and whether the way economic activity data was coded for people of different ages in the 2001 Census affected the categorisation of household reference persons (HRPs) by household type and age.

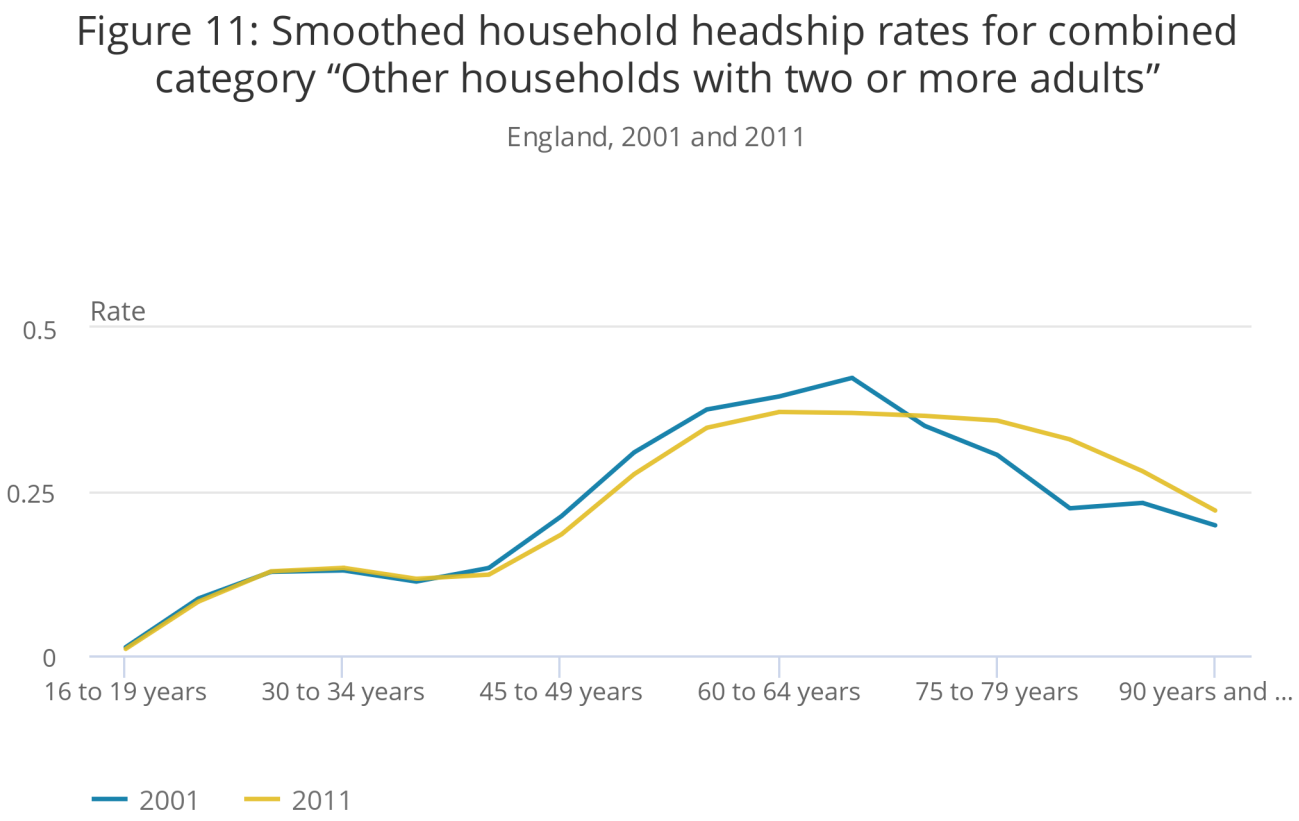
To resolve the issue for the 2016-based household projections, we have merged the following three categories to create the overarching category “Other households with two or more adults”:

- One family and no others: Couple households: No dependent children
- Couple and one or more other adults: No dependent children
- Other households with two or more adults

Although the headship rates for “Couple and one or more other adults: No dependent children” showed no unusual trends, it seemed illogical to maintain the separation between this category when the other two categories of households containing two or more adults and no dependent children were being merged. Figure 11 shows the age distribution for the new household grouping “Other households with two or more adults”.

Figure 11: Smoothed household headship rates for combined category “Other households with two or more adults”

England, 2001 and 2011



Source: Office for National Statistics

We are planning to review the household type breakdowns provided as part of future household projections. Part of this review will involve ensuring that consistent breakdowns and categorisations can be produced across multiple years and data sources.

On request, we may be able to produce a breakdown of the new merged category “Other households with two or more adults” to the three original categories, on the understanding that caution should be exercised when interpreting the findings from two of the three categories, which appear to be inconsistent between the censuses. We are continuing to investigate the cause of this inconsistency and will provide accompanying guidance where possible to help with the interpretation of the figures. These concerns do not apply to the published aggregate category of “Other households with two or more adults”.

In summary, the Stage 2 2016-based household projections are divided in to six household types:

- One-person households: male
- One-person households: female
- Other households with two or more adults
- Households with one dependent child
- Households with two dependent children
- Households with three or more dependent children

Table 2 shows how the 2016-based household types are aggregated from the 2014-based household types, as well as the 2001 and 2011 source data.

Table 2: Household type aggregations

2016-based household type	2014-based household type	2001 Census table C1092_01 household type	2011 Census table CT0691 household type
One-person households: male	One-person households: male	One-person households: male	One-person households: male
One-person households: female	One-person households: female	One-person households: female	One-person households: female
Other households with two or more adults	One family and no others: Couple households: No dependent children,	One family and no others: Couple households: No children, One family and no others: Couple households: All children non-dependent,	One family and no others: Couple households: No children,
	A couple and one or more other adults: No dependent children and	One family and no others: Lone parent households: All children non-dependent,	Couple and one or more other adult households: No children,
	Other households with two or more adults	A couple and one or more other adults: No children,	Other households (with two or more adults) and
		A lone parent and one or more other adults: no dependent children,	Other household types
		Other households with two adults,	
		Other households with three or more adults and	
		Other households	
Households with one dependent child	Households with one dependent child	One family and no others: Couple households: with one dependent child,	Households with one dependent child
		One family and no others: Lone parent households: with one dependent child,	
		A couple and one or more other adults: with one dependent child and	
		A lone parent and one or more other adults: with one dependent child	
Households with two dependent children	Households with two dependent children	One family and no others: Couple households: with two dependent children,	Households with two dependent children
		One family and no others: Lone parent households: with two dependent children,	
		A couple and one or more other adults: with two dependent children and	
		A lone parent and one or more other adults: with two dependent children	
Households with three or more dependent children	Households with three or more dependent children	One family and no others: Couple households: with three or more dependent children,	Households with three or more dependent children
		One family and no others: Lone parent households: with three or more dependent children,	
		A couple and one or more other adults: with three or more dependent children and	

A lone parent and one or more other adults:
with three or more dependent children

Constraining to Stage 1 totals

Once base headship rates have been produced, smoothed and projected forward, they are multiplied by the household population for each quinary age, sex, geography and year grouping to produce initial projected numbers of households by type. These initial projected numbers of households are then constrained to the projected household totals produced in Stage 1.

For example, in local authority A, the projected number of households headed by 50- to 54-year-old males in 2020 in the Stage 1 projections was 1,078. The initial Stage 2 household projections showed the following household type breakdown for households headed by 50- to 54-year-olds in local authority A in 2020:

- One-person households: male – 180 households
- One-person households: female – 200 households
- Other households with two or more adults – 430 households
- Households with one dependent child – 140 households
- Households with two dependent children – 110 households
- Households with three or more dependent children – 40 households
- Total – 1,100 households

Therefore, the effect of the constraining to the Stage 1 total of 1,078 households in this example would be to reduce the size of each category of household type breakdown by 2%.

In the 2016-based household projections, Stage 1 and Stage 2 figures share the same definition of HRP; that is, the oldest economically active person in the household. This means that the adjustments made at this point in the 2014-based household projections methodology to accommodate the different HRP definitions are no longer required.

Although headship rates are calculated separately for males and females, household projections by household type are then merged for males and females, prior to the application of minimum adult and child checks (except for one-person households, for which the sex split is retained). This is because our research identified some implausible trends between males and females for some of the disaggregated household types that were merged. This approach also retains consistency with the 2014-based household projections.

Minimum adult and child checks

The next part of the Stage 2 processing is to ensure that the minimum number of adults and children implied by the projected household type breakdown for each geography and year does not exceed the number of adults and children in the projected household population for that geography and year.

A dependent child is defined as any person aged 0 to 15 years living in a household, or a person aged 16 to 18 years in full-time education and living in a family with their parent(s) or grandparent(s). It does not include any people aged 16 to 18 years who have a spouse, partner or child living in the household.

As household population data include an age breakdown for those aged 16 to 19 years, we are required to make an assumption about the future numbers of 16- to 19-year-olds who would be considered dependent children. To do this, we use a combination of 2001 and 2011 Census data and Annual Population Survey (APS) data. For each local authority, we calculate the estimated proportion of people aged 16 to 19 years who are dependent children, using census data for the years 2001 and 2011 and APS data for the years 2004 to 2010 and 2012 to 2016. APS data were not available for the years 2002 and 2003, so figures for these years are interpolated between the 2001 Census estimate and 2004 APS estimate.

APS estimates based on a sample of less than three people were suppressed and missing values were linearly interpolated between the nearest years with APS or Census data. Due to fluctuations in the APS data arising from small sample sizes, we smoothed the APS data using a three-year moving average, apart from for the last year of data (2016) where we took the average of 2015 and 2016. We held constant the averaged 2015 to 2016 proportion of dependent children for each local authority in future years of the projection period and applied this proportion to the household population estimates of the number of 16- to 19-year-olds.

The number of dependent children in each local authority and year in the household population is then compared with the minimum number of dependent children implied by the household type breakdown for that local authority and year. When the latter is greater than the former, the number of households with dependent children is reduced by the number of children in excess of the household population.

For example, in local authority A in 2040, there is a household population of 1,000 dependent children, but the projected household type breakdown for 2040 implies a minimum of 1,050 dependent children. Therefore, we remove 50 households with dependent children from the household types with dependent children and allocate them to the household types that do not have dependent children. For each age group, within households that have dependent children, the proportion of each household type (one, two and three or more dependent children) is held constant. The same is true for the proportion of each household type (one-person male, one-person female and households with two or more adults and no dependent children) within households that do not have dependent children.

The result is that households are reallocated in a way that maintains the existing age distribution of households with one, two and three dependent children. For example, if 5% of households with dependent children in local authority A are households with two dependent children headed by someone aged 30 to 34 years old, then 5% of the 50 households being removed would be removed from this category (2.5 households).

Similarly, when adding the 50 households to the categories that do not have dependent children, the households would be added according to the age and household type distribution for that local authority and year. For example, if 25% of households without dependent children in local authority A in 2040 were one-person female households, then 25% of the 50 households being reallocated would be added to this category (12.5 households).

Therefore, this process does not affect the overall number of households projected for a given area and geography, only the household type breakdown within that total. An average of 2.5% of local authorities per year required minimum child adjustments. Where adjustments were required for a local authority in a given year, the minimum number of dependent children implied by the household type breakdown was 1.8% higher on average than the number of children in the household population.

Once the projections have been adjusted for the number of children in the household population, we then compare the minimum number of adults implied by the household projections with the number of adults in the household population. Adults are anyone aged 19 years and over, plus the proportion of 16- to 18-year-olds who were not considered to be dependent children. No adjustments were required in any years of the projection period to reduce the minimum number of adults implied by the household type breakdowns.

Limitations of minimum adult and child checks

We recognise that there are limitations to the way in which we have applied the minimum adult and child checks. Firstly, we remove the same number of households from household types with dependent children as there are excess dependent children. This means that we actually remove more children than the excess implied, because in removing a household with two dependent children, we reduce the number of excess children by two, not one. On the other hand, removing more children than the minimum excess implied may account more effectively for households with three or more children, some of which will actually have four, five or more children.

Similarly, where the minimum number of children implied by the household type breakdown is equal to, or only slightly lower than, the household population of children, we make no adjustment. This means we may not be making enough of an allowance for those households with three or more dependent children who will have four, five or more children.

For the minimum number of adults, we have assumed that the minimum number of adults in households with dependent children is one and that the minimum number of adults in households with two or more adults and no dependent children is two. We recognise that this is likely to indicate a lower minimum number of adults than is reasonable for many local authorities. Using alternative household type breakdowns in the future will allow us to explore using more granular data about the minimum numbers of adults in households, to provide more detailed checks.

We will continue to review the most effective ways of applying minimum adult and child checks to household projections as part of our future research.

Final household headship rates

The Stage 2 household headship rates presented in the detailed data for modelling and analysis are calculated at the end of the Stage 2 processing, once all constraining and adjustments have been applied.

8 . Sensitivity analysis and variant household projections

This section contains similar analysis to that included in Section 4 (pages 24 to 25) of the Household Projections 2014-based: Methodological Report (PDF, 781.7KB). Sensitivity analysis and variant household projections are provided to help users assess the uncertainty and variation in household projections.

Sensitivity analysis

To help users, we have carried out sensitivity analysis to help distinguish the effects of the changes made to the 2016-based household projections methodology from the effects of the move from using 2014-based subnational population projections (SNPPs) to 2016-based SNPPs. Two tests were carried out.

In test one, the 2014-based SNPPs and unrevised mid-year population estimates (MYEs) were input through the 2016-based household projections methods, instead of the 2016-based SNPPs and revised MYEs.

In test two, the 2014-based Stage 2 age-only household headship rates were applied to the 2016-based SNPPs to isolate the effects of the methodological changes to the household formation rates on the resulting projection.

This analysis was run at local authority level to help users understand the impact of the changes to the MYEs, SNPPs and household formation on the 2016-based household projections. The results of the sensitivity analysis for local authorities are available in tables 429a and 429b, with detailed data for modelling and analytical purposes available for both the principal projection and sensitivity analysis.

Table 3: Projected number of households by projection type, England, 2014 and 2039

Projection type	Projected households (thousands)		Total change (thousands)	Average annual change (thousands)	Percentage change
	2014	2039			
2016-based household projections	22,488	26,572	4,084	163	18.2%
Test one: 2014-based SNPPs and unrevised MYEs with 2016-based methods	22,488	27,205	4,717	189	21.0%
Test two: 2016-based SNPPs and revised MYEs with 2014-based Stage 2 household headship rates	22,663	27,238	4,575	183	20.2%
2014-based household projections	22,746	28,004	5,257	210	23.1%

Source: Office for National Statistics

Notes:

1. Figures may not sum due to rounding.

Table 4: Projected household population by projection type, England, 2014 and 2039

Projection type	Projected household population (thousands)		Total change (thousands)	Average annual change (thousands)	Percentage change
	2014	2039			
2016-based household projections	53,342	60,271	6,929	277	13.00%
Test one: 2014-based SNPPs and unrevised MYEs with 2016-based methods	53,342	61,945	8,603	344	16.10%
Test two: 2016-based SNPPs and revised MYEs with 2014-based Stage 2 household headship rates	53,342	60,271	6,929	277	13.00%
2014-based household projections	53,351	62,027	8,675	347	16.30%

Source: Office for National Statistics

Notes:

1. Figures may not sum due to rounding

Table 5: Projected average household size by projection type, England, 2014 and 2039

Projection type	Projected average household size	
	2014	2039
2016-based household projections	2.37	2.27
Test one: 2014-based SNPPs and unrevised MYEs with 2016-based methods	2.37	2.28
Test two: 2016-based SNPPs and revised MYEs with 2014-based Stage 2 household headship rates	2.35	2.21
2014-based household projections	2.35	2.21

Source: Office for National Statistics

Variant national household projections

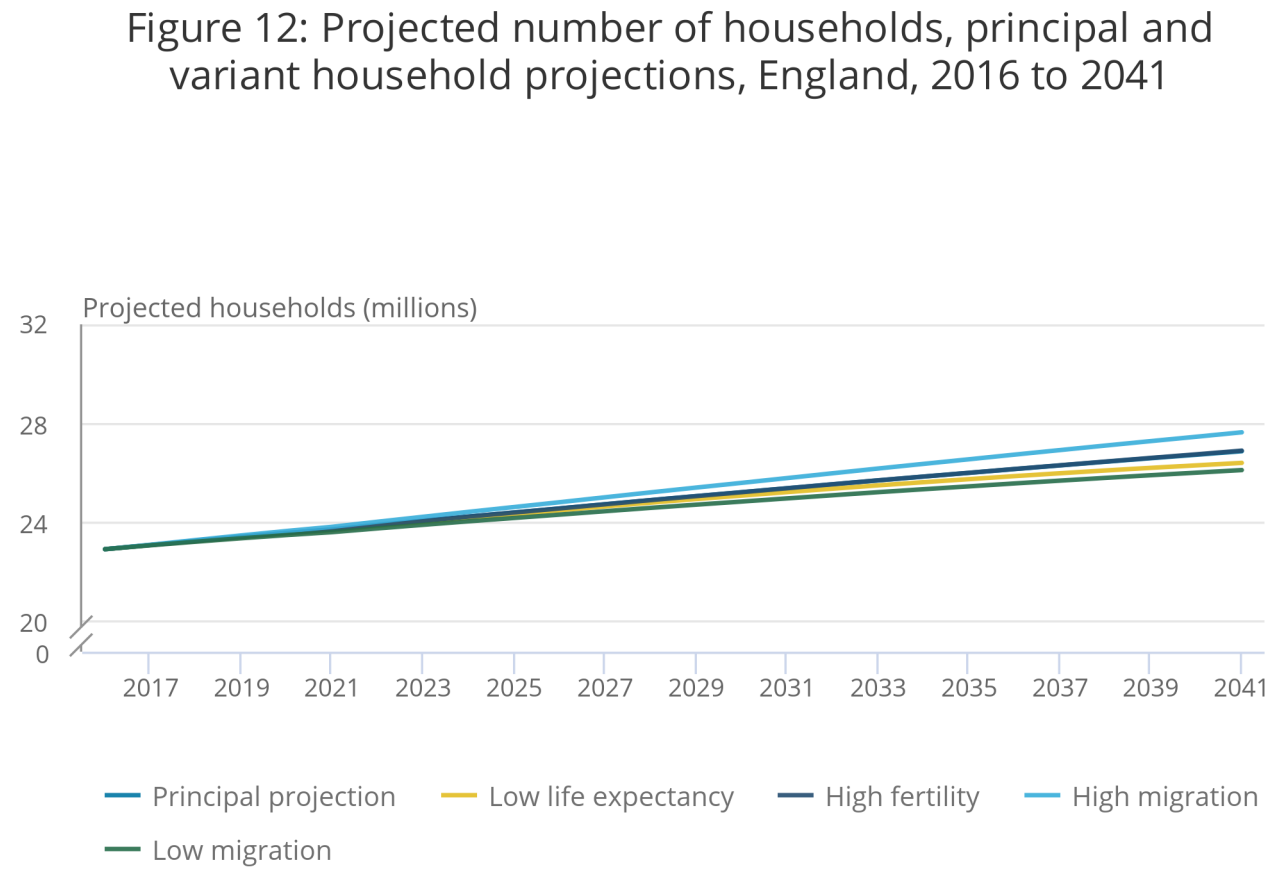
Variant national population projections (NPPs) are based on alternative assumptions about future fertility, mortality and migration for England. These illustrate what the population of England would look like if one or more assumptions are varied, and provide an indication of uncertainty.

Variant NPPs are produced for England and can be input into the household projections system to produce household projection variants alongside the principal household projection. Applying the communal establishment assumptions and household representative rates from the household projections to the variant NPPs gives a broad indication of the sensitivity of the household projections to demographic assumptions at national level.

Five variant NPPs have been produced as household projections:

- low life expectancy
- high fertility
- high migration
- low migration
- zero migration

Figure 12: Projected number of households, principal and variant household projections, England, 2016 to 2041



Source: Office for National Statistics

Figure 12 shows that the high migration variant projects 31,000 additional households per year, while the low migration variant reduces the principal projection by the same amount per year. The low life expectancy and high fertility assumptions have less impact on the household projections than the variant migration assumptions.

Table 6: Assumptions and results of principal and variant household projections, England

Variant	Assumptions				Results	
	Fertility [1]	Male life expectancy [2]	Female life expectancy [3]	Migration [4]	Households in 2041 (thousands)	Annual average change 2016 to 2041 (thousands)
Principal	1.85	83.6	86.4	152,000	26,855	159
Low life expectancy	1.85	81.8	84.8	152,000	26,383	140
High fertility	1.95	83.6	86.4	152,000	26,880	160
High migration	1.85	83.6	86.4	214,500	27,623	190
Low migration	1.85	83.6	86.4	89,500	26,092	128

Source: Office for National Statistics

Notes:

1. “Fertility” refers to long-term average completed family size (number of children per woman).

2. “Male life expectancy” refers to period life expectancy at birth for males in 2041.

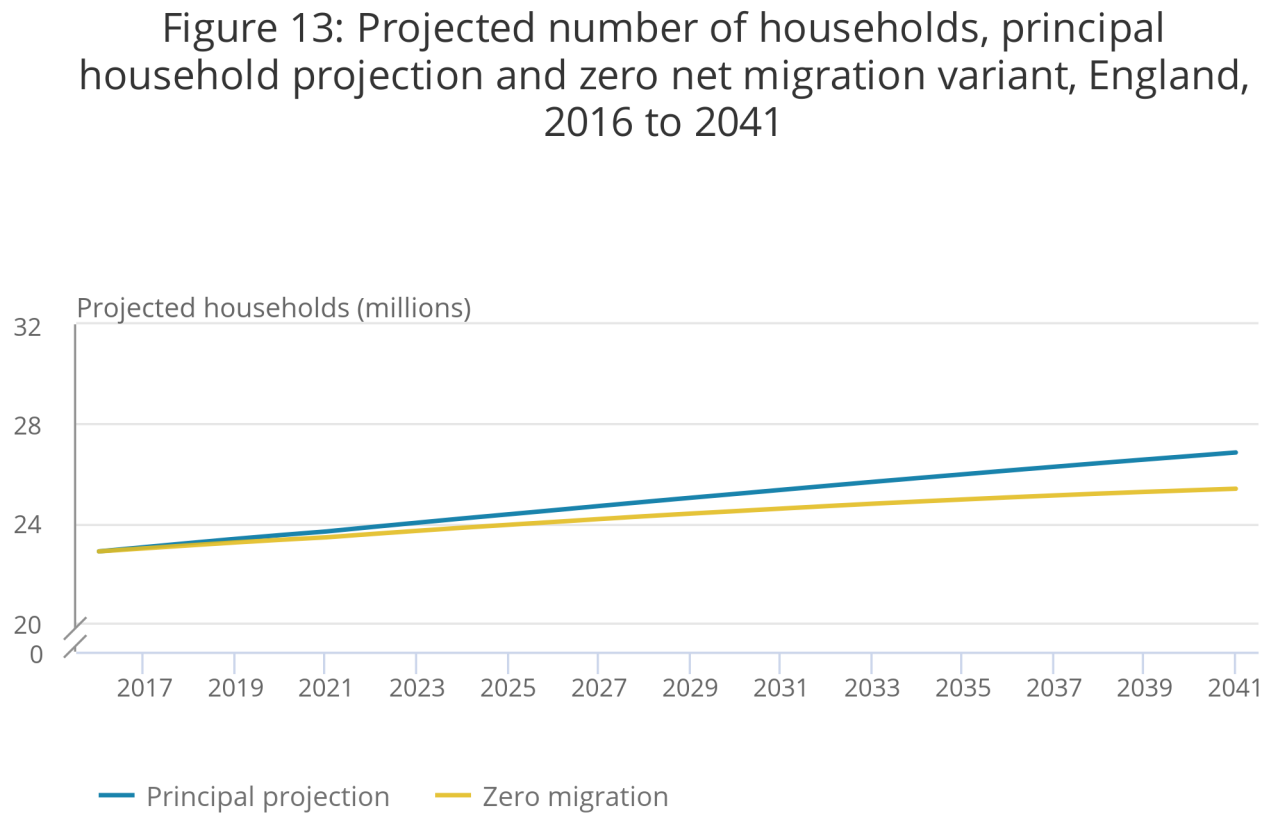
3. “Female life expectancy” refers to period life expectancy at birth for females in 2041.

4. “Migration” refers to the long-term assumption for net long-term migration (including asylum seekers), which applies from the year mid-2023 onwards in the NPPs.

Impact of migration – zero migration variant

The zero migration variant allows us to illustrate the proportion of household growth in the principal household projection that can be attributed to migration. The zero migration variant NPP for England shows the projected change in population that would occur as a result of natural change only. Therefore, the migration referred to in the “zero migration” variant includes both international migration (moves between England and other countries) and cross-border migration within the UK (moves between England and Wales, Scotland and Northern Ireland).

Figure 13: Projected number of households, principal household projection and zero net migration variant, England, 2016 to 2041



Source: Office for National Statistics

Figure 13 shows that the zero migration variant assumptions have a larger impact on the projected number of households compared with the other variants, resulting in 58,000 fewer households per year than the principal projection. This suggests that 37% of the annual average change in the number of households from 2016 to 2041 can be attributed to migration and that 63% can be attributed to natural change (the difference between the number of births and number of deaths).

Table 7: Assumptions and results of principal and variant household projections, England

Variant	Assumptions				Results	
	Fertility[1]	Male life expectancy[2]	Female life expectancy[3]	Migration	Households in 2041 (thousands)	Annual average change 2016 to 2041 (thousands)
Principal	1.85	83.6	86.4	152,000	26,855	159
Zero migration	1.85	83.6	86.4	0	25,400	101

Source: Office for National Statistics

Notes

1. “Fertility” refers to long-term average completed family size (number of children per woman). Back to table

2. “Male life expectancy” refers to period life expectancy at birth for males in 2041.,“Female life expectancy” refers to period life expectancy at birth for females in 2041.,“Migration” refers to the long-term assumption for net long-term migration (including asylum seekers), which applies from the year mid-2023 onwards in the NPPs. Back to table

Variant subnational household projections

Variant subnational household projections were published on 16 May 2019. These are based on the subnational population projection variants published on 9 April 2019. Four subnational variant household projections have been produced:

- 10-year migration
- high migration
- low migration
- continuous projection of the HRRs which were held constant from 2022 onwards in the principal projection

The 10-year migration variant is based on 10 years of historical data rather than the five years that are used in the principal projection. It resulted from user demand from the subnational population projections to analyse differences resulting from alternative migration assumptions. Full details can be found in the variant subnational household projection statistical bulletin.

9 . Assumptions and properties of the household projections methodology

Household projections show the number of households there would be in England in the future if a set of assumptions about the size and structure of the population and that population’s patterns of household formation were realised in practice.

As with any set of projections, the household projections are subject to error if any of the components used to produce them – usual resident population, household population, or household representative rate – contain error. One of the main reasons why a component of the household projections might be subject to error is because the assumptions made in their production do not play out in practice.

The assumptions used in household projections are based on past demographic trends. However, demographic behaviour is inherently uncertain, so projections become increasingly uncertain the further they are carried forward[1]. This is particularly the case for smaller geographical areas and detailed age, sex and household type breakdowns.

Assumptions made in the production of household projections for England

- The mid-year population estimates (MYEs) and subnational population projections (SNPPs) are an accurate reflection of the past and projected size and structure of the usual resident population of England by age and sex.

- The size of the communal establishment (CE) population aged 0 to 74 years by sex for 2001 to 2010 will be the same as it was in the 2001 Census.

- The size of the CE population aged 0 to 74 years by sex for 2011 to 2041 will be the same as it was in the 2011 Census.

- The proportion of those aged 75 years and over by sex living in CEs for 2001 to 2010 will be the same as it was in the 2001 Census.

- The proportion of those aged 75 years and over by sex living in CEs for 2011 to 2041 will be the same as it was in the 2011 Census.

- The age structure of the prison population aged 0 to 74 years serving sentences of six months or more will be similar across local authorities, as a national distribution of age and sentence length is applied to all local authorities.

- Household representative rates (HRRs) calculated by age, sex and geography will produce an accurate reflection of the numbers of households in future years.

- Using two years of Census data (2001 and 2011) will provide a long enough trend to provide a reasonably accurate projection of HRRs for the years 2011 to 2021.

- HRRs after 2021 are constant, reflecting the uncertainty of household formation patterns in future years.

- Projected numbers of households for England are more accurate than those for regions, which in turn are more accurate than those for local authorities; therefore, geographical constraining is applied to figures for regions and local authorities.

- Headship rates calculated by age, sex , household type and geography will produce an accurate reflection of the numbers of households in future years.

- Using two years of census data (2001 and 2011) will provide a long enough trend to provide a reasonably accurate projection of headship rates for the years 2011 to 2021.

- Headship rates after 2021 (prior to the application of constraining and minimum adult and child checks) are constant, reflecting the uncertainty of household formation patterns in future years.

- Projected numbers of households by age and geography from Stage 1 are more accurate than those from the aggregated Stage 2 figures; therefore, initial Stage 2 projections are constrained to Stage 1 totals.

- The proportion of 16- to 18-year-olds who are dependent children in the years 2017 to 2041 will remain constant at the 2015 to 2016 levels calculated from Annual Population Survey (APS) data.

- The distribution of household types within households with and without dependent children remains the same after adjustments to account for minimum numbers of children have been applied.

- Where there are more dependent children implied by the projected numbers of households than there are in the household population, the number of households removed should be equal to the excess number of dependent children.

- Where the minimum number of dependent children implied by the household type breakdown is equal to, or only slightly lower than, the household population of dependent children, no adjustment is required.

- The minimum number of adults implied by a household with dependent children is one.

Factors not accounted for in the household projections methodology

The household projections methodology makes no direct adjustments for the following:

- changes in the stock of dwellings and communal establishments (for example, new builds, demolitions and changes of use)
- future economic conditions
- future changes to the housing market, such as house prices or changes to the private or social renting sectors
- changes in marital status, income, economic activity or any other demographic factors of the population
- cohort effects

With regards to cohort effects, it should be noted that recent falls in HRRs for younger age groups may carry forward through a cohort process into older age groups in future years. If there is evidence in the future from the census or other data sources of cohort effects, it would be necessary to consider whether introducing cohort effects into the model would improve the household projections – especially given the additional complexity and data requirements that this approach would entail.

Properties of the household projections methodology

The HRR method used to produce the household projections has several basic characteristics that tend to shape the projections. For example:

- all other things being equal, the higher the adult population, the higher the number of households
- similarly, higher adult population growth results in a higher growth in numbers of households
- for a given population, the number of households will be determined by the age and sex composition of the population
- HRRs tend to be higher for older age groups (as shown in Figures 3 to 6 in Section 5)
- socio-demographic events can have a marked impact on the number of households given the size of the population

Notes about Assumptions and properties of the household projections methodology

1. This uncertainty also applies to population projections that feed in to the household projections, as discussed in National Population Projections Accuracy Report, published in July 2015, and in Fifty years of United Kingdom national population projections: how accurate have they been?.

10 . Methods used for household projections for other parts of the UK

The methods described in this article relate to household projections for England only. Household projections are produced separately for England, Wales, Scotland and Northern Ireland. Data table 401 brings together household projections published separately for the four countries (last updated 10 January 2019).

A user guide to the household projections across the UK has also been published on 27 August 2019, which compares the methods and data sources used across the four countries.

The latest data and information on data sources and methods for household projections for Wales, Scotland and Northern Ireland are available.

11 . Changes to household projections methodology

This section summarises the changes that have been made to the household projections methodology for the 2016-based household projections, compared with the 2014-based household projections. Further details about the changes made are provided in the relevant sections of this article.

A research article has also been published on 27 August 2019, which provides further analysis on the local authorities which experienced the largest change between the 2014-based and 2016-based household projections.

Table 8: Changes to household projections methodology

Element	2014-based household projections	2016-based household projections
Mid-year population estimates (MYEs)	Used MYEs for years up to and including 2013, including unrevised MYEs for mid-2012 and mid-2013. MYEs broken down by age, sex and marital status.	Uses 2001 to 2016 MYEs, including revised MYEs for mid-2012 to mid-2016. MYEs broken down by age and sex but not marital status.
Subnational population projections (SNPPs)	Used 2014-based SNPPs for mid-2014 to mid-2039, broken down by age, sex and marital status. The marital status breakdown was derived from 2008-based marital status projections.	Uses 2016-based SNPPs for mid-2016 to mid-2041, broken down by age and sex only. No marital status breakdown is used.
Age bands	Quinary age bands from ages 15 to 19 years through to 85 years and over.	Uses 16 to 19 years age band instead of 15 to 19 years, after which quinary age bands are used for 20 to 24 years through to 90 years and over.
Communal establishment (CE) assumptions	Assumed CE population stays constant at 2011 levels by age, sex and marital status for those aged 0 to 74 years. Assumed CE population stays constant at 2011 proportions by age, sex and marital status for those aged 75 years and over.	Makes the same assumptions as the 2014-based household projections, but applies the assumptions by age and sex, as opposed to by age, sex and marital status.
Prison population adjustments	One-off adjustments made for the years 2002 to 2008.	Adjustments made for the years 2012 to 2016, to account for changes in the prison population since the 2011 Census.
Definition of household reference person	Eldest male within the household, then the eldest female if there was no male.	Eldest economically active person in the household, then the eldest inactive person if there was no economically active person.
Base household representative rates (HRRs) – number of years of data used	Used data from the 1971, 1981, 1991, 2001 and 2011 Censuses, supplemented by Labour Force Survey (LFS) data.	Uses data from the 2001 and 2011 Censuses only. HRRs broken down by age and sex are smoothed across age groups.
Base household representative rates – demographic breakdowns used	HRRs were broken down by age, sex and marital status in the Stage 1 projections.	HRRs are broken down by age and sex only in the Stage 1 projections.
Projecting household representative rates forward	HRRs were projected forward using a combination of two fitted trends, combined using assumptions based on LFS data.	HRRs are projected forward using a two-point exponential model.
Geographical constraining	HRRs for regions and local authorities were constrained to HRRs for England.	Numbers of households for regions are constrained to the number of households in England. Numbers of households in local authorities are constrained to numbers of households by region.
Household types used for	One-person households: male,	One-person households: male,

Stage 2 projections	One-person households: female, One family and no others: Couple households: No dependent children, A couple and one or more other adults: No dependent children, Households with one dependent child, Households with two dependent children, Households with three or more dependent children and Other households with two or more adults	One-person households: female, Other households with two or more adults, Households with one dependent child, Households with two dependent children and Households with three or more dependent children
Base headship rates for Stage 2 projections	Uses data from the 2001 and 2011 Censuses only. Headship rates broken down by 10 -year age bands and eight household types.	Uses data from the 2001 and 2011 Censuses only. Headship rates broken down by five-year age bands and six household types, with base headship rates smoothed across ages as in the Stage 1 method.
Method for applying minimum adult and child checks	Projections adjusted so that the ratio of children in the household population to the number implied by the household projections is constant over the projection period, assuming the ratio stays the same as the estimates for 2011.	Where the minimum number of dependent children in each local authority and year implied by the household type distribution is greater than the number of dependent children in the household population, the number of households with dependent children is reduced by the size of the difference in the number of dependent children.
Method for calculating sex breakdown of one-person households	Male and female one-person household breakdown is calculated as part of the initial calculation of base headship rates.	The total number of one-person households is calculated as a base headship rate, with the sex breakdown calculated by applying the sex ratio of the household population for each age, local authority and year grouping to the number of one-person households.

Source: Office for National Statistics

12 . Input data sources

This section provides a list of all the input data sources used in the production of the 2016-based household projections for England, for users wishing to carry out their own analysis or modelling.

To produce the household population, the following data sources are used:

- mid-2001 to mid-2017 population estimates by age and sex, detailed time series
- 2016-based subnational population projections by age and sex
- 2001 Census data on communal establishment (CE) and total usual resident populations by age and sex
- 2011 Census data on CE and total usual resident populations by age and sex
- prison population data from offender management statistics quarterly

To produce base household representative rates (HRRs) and headship rates, the following data sources are used:

- 2001 Census data – household reference persons (HRPs) by age and sex; these data were obtained from 2001 Census commissioned table C1092_01 and this table is listed as a 2001 Census commissioned table and can be obtained free of charge from Census Customer Services
- 2001 Census data – household populations by age and sex
- 2011 Census data – HRPs by age and sex
- 2011 Census data – household populations by age and sex (the 2011 household population was derived by subtracting the CE population from the total usual resident population)

To calculate the minimum adult and child checks, the following data sources are used:

- Annual Population Survey (APS) data – estimates of the number of dependent children in households aged 16 to 18 years and people in households aged 16 to 19 years by local authority, England, 2004 to 2010 and 2011 to 2016
- 2001 Census data – numbers of dependent children aged 16 to 18 years and people aged 16 to 19 years in the household population by local authority, England
- 2011 Census data – numbers of dependent children aged 16 to 18 years and people aged 16 to 19 years in the household population by local authority, England

13 . Glossary

Average household size

The average household size is the average number of people within a household (including children). It is calculated by dividing the household population by the number of households for a given geography and/or age group.

Communal establishment (CE) population

The communal establishment population (also known as the institutional population) includes all people not living in private households. CEs provide managed residential accommodation, for example, nursing homes, student halls of residence, military barracks and prisons. The full definition of a CE can be found in the 2011 Census glossary.

Dependent child

Any person aged 0 to 15 years living in a household, or a person aged 16 to 18 years in full-time education and living in a family with their parent(s) or grandparent(s). It does not include any people aged 16 to 18 years who have a spouse, partner or child living in the household. References in this article to “child” or “children” should be assumed to refer to dependent children, unless otherwise specified.

Household

The household projections are based on the census definition of a household, which in 2011 was: “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% or more have their own kitchens (irrespective of whether there are other communal facilities) and 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.

A household must contain at least one person whose place of usual residence is at the address. A group of short-term residents living together is not classified as a household, and neither is a group of people at an address where only visitors are staying.

Household headship rate

Headship rates show the proportion of people in a particular demographic group (based on geography, quinary age group and household type) who were the household reference person (HRP). The only difference between household representative rates (HRRs) and headship rates is that HRRs are calculated by age, sex and geography and headship rates are calculated by age, sex, household type and geography.

Household population

The household population is the difference between the total usual resident population and the usual resident population living in communal establishments.

Household reference person (HRP)

The HRP is a person chosen for statistical reasons by virtue of economic activity, age and/or sex as the representative of a household. The 2016-based household projections define the HRP as the eldest economically active person in the household, then the eldest inactive person if there was no economically active person.

Past sets of Stage 1 household projections defined the HRP as the as the eldest male within the household, then the eldest female if there was no male. The full explanation of the current HRP definition can be found on page 23 of the 2011 Census Glossary.

Household representative rate (HRR)

The HRR is the proportion of people in a particular demographic group (for the 2016-based household projections this is based on geography, age group and sex) who were the HRP. The value of the HRR will be between zero and one.

Household type

Household types classify each household by the number of adults and dependent children living within it and the nature of those relationships.

Institutional population

The institutional population is another name for the communal establishment population, used more frequently in past sets of household projections.

Quinary age group

The five-year age groups used in the 2016-based household projections are:

- 16- to 19-year-olds
- 20- to 24-year-olds
- 25- to 29-year-olds
- 30- to 34-year-olds
- 35- to 39-year-olds
- 40- to 44-year-olds
- 45- to 49-year-olds
- 50- to 54-year-olds
- 55- to 59-year-olds
- 60- to 64-year-olds
- 65- to 69-year-olds
- 70- to 74-year-olds
- 75- to 79-year-olds
- 80- to 84-year-olds
- 85- to 89-year-olds
- those aged 90 years and over

Stage 1

Stage 1 household projections provide projected numbers of households by the age group and sex of the household reference person, for England, regions and local authorities.

Stage 2

Stage 2 household projections provide projected numbers of households by household type, for England, regions and local authorities.

Usual resident population

The usual resident population includes people who reside, or intend to reside, in the country for at least 12 months, whatever their nationality.