Beyond 2011: Final Options Report (O4)

April 2014

Background

The UK Statistics Authority asked the Office for National Statistics (ONS) to review the options for the future provision of population statistics and the next census in England and Wales after the 2011 Census was concluded.

ONS launched the Beyond 2011 Programme of research and reviews, including a major public consultation at the end of 2013. The results of this consultation can be found here .The Programme examined and compared various approaches to counting the population, both here and overseas, engaged with a diverse group of users, commentators and public bodies, commissioned a major independent review of methodology (the Skinner Review) and undertook quantitative and qualitative research into public attitudes to the use of personal data for statistics.

Subsequently the National Statistician recommended to the Board of the UK Statistics Authority that the future provision of population statistics and the next census should comprise:

- An online census of all households and communal establishments in England and Wales in 2021 as a modern successor to the traditional, paper-based decennial census. ONS recognises that special care would need to be taken to support those who are unable to complete the census online.
- Increased use of administrative data and surveys in order to enhance the statistics from the 2021 Census and improve annual statistics between censuses.

Further research is to be carried out over the coming months and years to determine the most appropriate blend of methods and data sources.

About this paper

This paper provides further detail underpinning this recommendation and is the fourth and final report (O4) reviewing the statistical options assessed by the Beyond 2011 Programme.

An overview of research during this period is provided in Beyond 2011 Statistical Research Update (Paper M13) with more detailed methods, research and findings to be published in summer 2014.

For more information

Search Beyond 2011 @ www.ons.gov.uk or contact : beyond2011@ons.gov.uk

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OPTIONS

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Office for National Statistics

1 Executive Summary

In March 2014 the National Statistician recommended that future needs for population statistics should be met by an online 2021 Census, with increased use of administrative data and surveys to enhance statistics from the census and improve annual statistics between censuses (National Statistician's Recommendation, March 2014). This paper provides further detail underpinning this recommendation and is the fourth and final report (O4) reviewing the statistical options assessed by the Beyond 2011 Programme.

Beyond 2011: Narrowing down the Options (Paper O3) provides an overview of the options that have been considered within the Programme, and describes how they were narrowed down to the two approaches included in the consultation 'the census and future provision of population statistics in England and Wales' (C1, 2013).This assessment brings together the evidence currently available and reflects the progress made since the last options assessment report published in July 2013 (Beyond 2011 Options Report O2, July 2013). An overview of research during this period is provided in Beyond 2011 Statistical Research Update (Paper M13) with more detailed methods, research and findings to be published in summer 2014.

For this assessment, new quality standards have been developed for population estimates by age and sex, and a new criterion relating to compliance with the Code of Practice for Official Statistics has been introduced. The evaluation criteria and quality standards have enabled a systematic assessment of what the two approaches could deliver, and identification of where risks would lie in implementing each of them. In summary:

- Significant progress has been made in understanding the outputs that could be delivered from a census using administrative data and surveys. It is clear that it would not be able to produce multivariate statistics for small population subgroups or geographic areas which are a key requirement for users
- The Independent Review of Methodology led by Chris Skinner concluded that there was not sufficient evidence that a census using administrative data and surveys provides a methodologically sound basis for replacing the 2011 Census methodology at present
- An online census once a decade would be designed to at least meet the quality standards achieved in the current system.
- The legislative risk is greater for a census using administrative data and surveys as additional legislation would be required to enable further data sharing and compulsory surveys. An online census once a decade could be implemented using existing legislation and secondary legislation required, as for any census.
- There is also greater risk associated with a census using administrative data and surveys in complying with the Code of Practice for Official Statistics compared with existing, compliant census methods. Further research is required to develop methods for quality assurance, quality measures and to understand the impact of methodological change

The National Statistician recommended in March 2014 that we should make best use of all sources, increasing the use of administrative data and surveys to enhance statistics from the 2021 Census and improve statistics between censuses.

2 Introduction

In March 2014 the National Statistician recommended that future needs for population statistics should be met by an online 2021 Census, with increased use of administrative data and surveys to enhance statistics from the census and improve annual statistics between censuses (National Statistician's Recommendation, March 2014). This paper provides further detail underpinning this recommendation and is the fourth and final report (O4) reviewing the statistical options assessed by the Beyond 2011 Programme.

The second Options Report in July 2013 (Paper O2) refined the evaluation criteria and drew together the available evidence to assess each of the six shortlisted options for the production of population and socio-demographic statistics. Beyond 2011: Narrowing down the Options (Paper O3) published in November 2013 described how they were narrowed down to the two approaches for a census included in a public consultation which ran from September to December 2013:

- once a decade, like that conducted in 2011, but primarily online
- using existing government data and compulsory annual surveys.

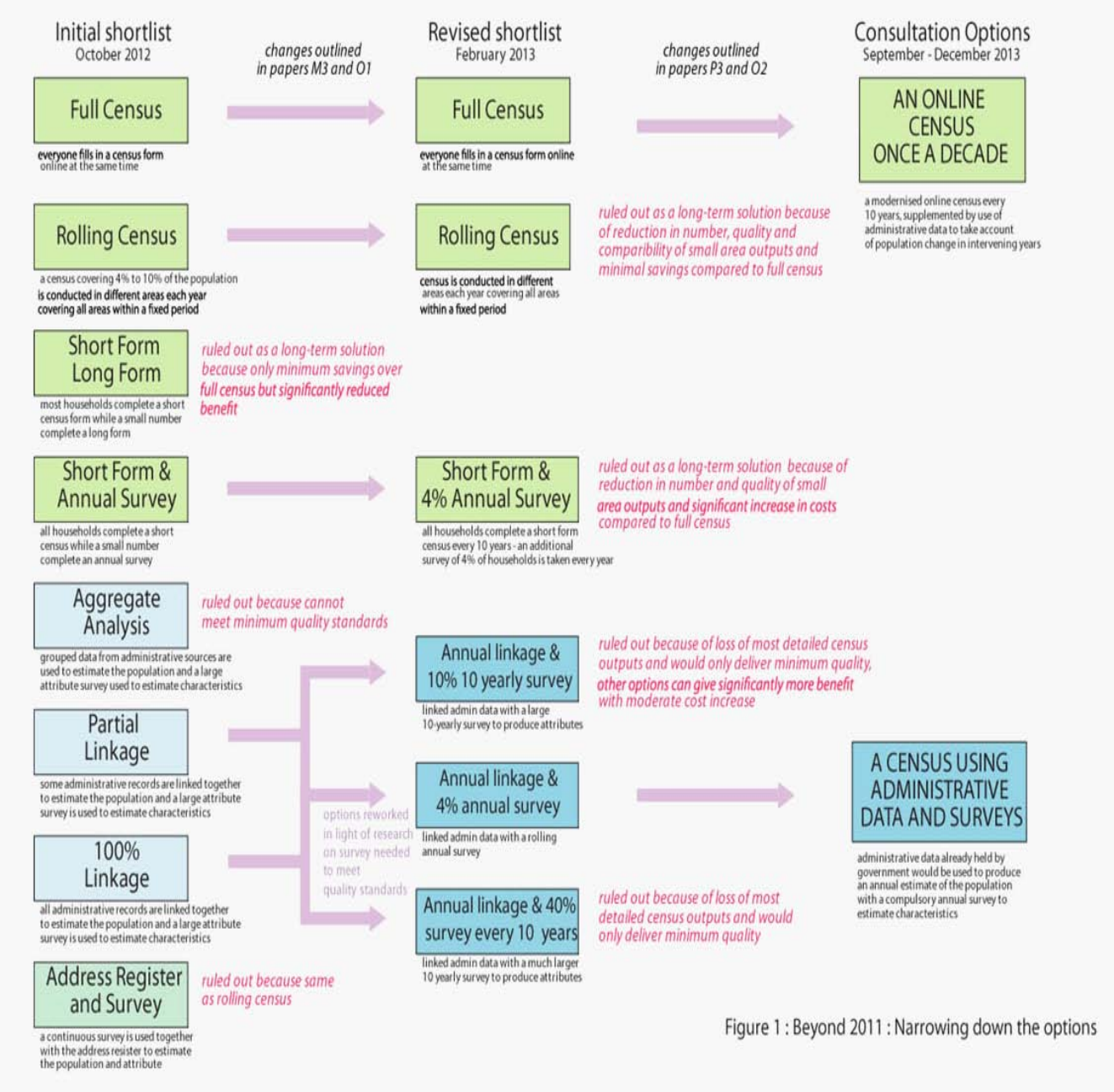
Figure 1, taken from Beyond 2011: Narrowing down the Options (Paper O3) summarises this process.

Responses from the consultation have been included as evidence in the assessment of the two options where appropriate, but were not included in further development of the evaluation criteria due to the timing of the consultation period.

This report presents these further refinements to the evaluation criteria and draws together the evidence available. Section 3 explains the evaluation criteria used in this assessment and introduces a new criterion relating to compliance with the Code of Practice for Official Statistics. Section 4 presents the evidence supporting the assessment of the options. The conclusions from this assessment are drawn together in Section 5.

Evidence to support the assessment is reported in Beyond 2011 Statistical Research Update (Paper M13). Further detail of the methods, research and findings will be published in summer 2014.

Figure 1 Beyond 2011: Narrowing down the options

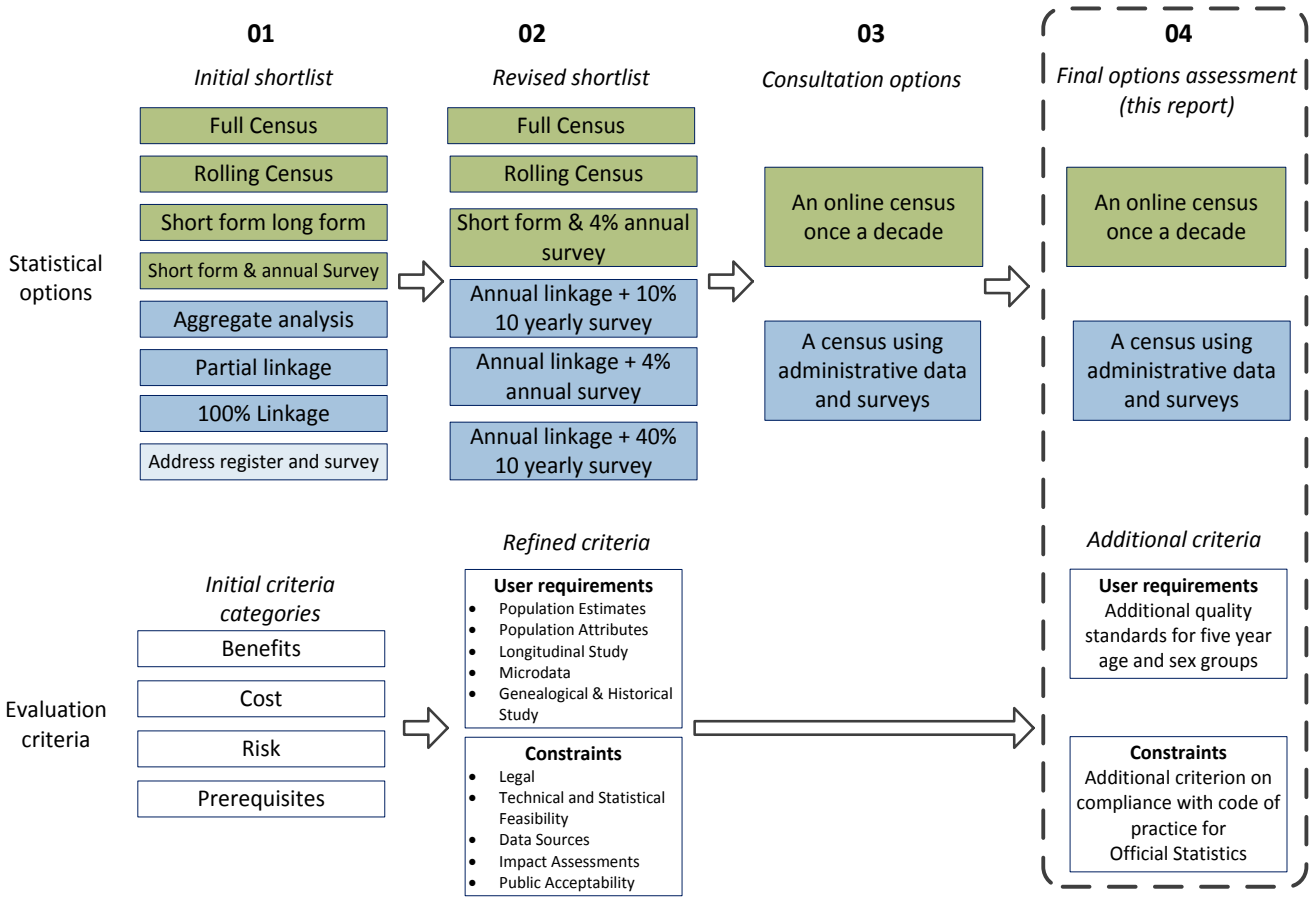


3 Beyond 2011 evaluation criteria and assessment process

3.1 Introduction to the assessment process

This is the fourth and final options report (O4) reviewing the statistical options assessed by the Beyond 2011 Programme. Figure 2 illustrates the options and criteria used in previous assessments. Further information on the process of narrowing down the options and how the evaluation criteria and quality standards have evolved is available in Beyond 2011 Options Reports O1 – O3.

Figure 2 Summary of options assessment process



3.2 Quality standards and evaluation criteria

In the last assessment of options in July 2013 (Beyond 2011 Options Report 2; Paper O2) the evaluation criterion for population estimates included quality standards for total LA and national estimates only. Since the last assessment this criterion has been revised to include quality standards for LA and national estimates by age and sex group. Further information on how these quality standards were derived and quantified is provided in Appendix A.

A new criterion relating to compliance with the Code of Practice for Official Statistics has been introduced as set out in section 3.4 and highlighted in Table 1.

Ensuring that we have an appropriate set of criteria has been essential to ensure a thorough evaluation. The criteria were developed based on lessons learned from the options assessment process and through user engagement. Responses from the public consultation between September and December 2013 were not included in further refinements to evaluation criteria. These evaluation criteria are shown below in Table 1 with further details in following sections and in Beyond 2011 Options Report 2; Paper O2.

Table 1: Evaluation criteria

User requirements	Constraints
Population estimates	Legal
Population characteristics	Technical and statistical feasibility
Anonymised microdata[1]	Data sources
Longitudinal Study (LS)	Impact assessments
Genealogical and historical study	Public acceptability
	Compliance with Code of Practice[2]

3.3 The assessment process

The options were assessed individually against each of the criteria in Table 1. This process resulted in a red/amber/green (RAG) assessment against each criterion, unless there was insufficient evidence in which case a blue status was assigned.

A full list of the user requirements evaluation criteria is included in Figure 3 (p14) and a full list of the constraints criteria is included in Figure 4 (p23). For each criterion, a rating was assigned along with supporting evidence. Table 2 sets out the high level ratings used.

Table 2: RAG status definitions

Rating	Description
Green	No issues and / or criterion fully met
Amber	Some minor issues and / or criterion partially met

[1] For example the Samples of Anonymised Records (SARs) http://www.ons.gov.uk/ons/guide-method/census/census-2001/data-and-products/data-and-product-catalogue/microdata/samples-of-anonymised-records/samples-of-anonymised-records.html

[2] The Compliance with the Code of Practice criterion was introduced in this round of assessment.

Red	Significant issues and / or criterion is not met
Blue	Unable to rate at this point in time

This assessment of the two census approaches included in the public consultation brings together the research completed to date and provides supporting evidence for the recommendation published in March 2014.

High level costs and benefits of the two approaches were published as part of the consultation. These will be refined over the coming months and years as more detailed plans are developed.

3.4 User requirements

User requirements are expressed in terms of the quality of the outputs that would be produced from the two approaches. The quality of both the population estimates and the population characteristics are assessed against the quality standards presented in Appendix A and incorporate elements for accuracy, geography and frequency.

User requirements also include assessment of the extent to which an option can make anonymised microdata and longitudinal data available for research as well as how it might meet needs associated with genealogical and historical study in the future.

3.5 Constraints

The constraints criteria focus on the challenges and risks associated with recommending and implementing an option. The risks considered include the legal requirements for statistical outputs that must be met by an option, the legal framework necessary to implement an option and the technical and statistical feasibility of an option.

There are also constraints associated with:

- continued access to, and stability of, key administrative data sources
- privacy, equality and environmental impact
- public acceptability.

A new criterion relating to compliance of the approach with the Code of Practice for Official Statistics[3] has been introduced for this assessment. Under the Statistics and Registration Service Act 2007, the UK Statistics Authority has a statutory duty to assess statistics against the Code of Practice for Official Statistics, to determine whether the statistics can be designated as National Statistics.

A series of special assessments of the 2011 Census in the UK were undertaken to assess compliance with the code of practice by looking at plans and processes in different phases of the census programme. Statistics from the 2011 Census were compliant with the Code of Practice and designated National Statistics.

[3] Further information on ONS compliance with the UK Statistics Authority Code of Practice for Official Statistics is available at http://www.ons.gov.uk/ons/guide-method/the-national-statistics-standard/code-of-practice/index.html

At this research stage of the Programme there is insufficient evidence to undertake a full assessment of the two approaches against the Code of Practice because many details of the approach are still to be determined including, for example, the questions that would be asked in a census or annual surveys. This is reflected in the RAG statuses defined in Table 3.

Table 3: RAG statuses for Compliance with Code of Practice criterion

Rating	The extent to which the option is (or could be) compliant with the Code of Practice for Official Statistics
Green	Full compliance with code of practice likely
Amber	Some issues making compliance with code of practice difficult but could be resolved within required timeframe
Red	Significant issues making compliance with code of practice unlikely
Blue	Unable to rate at this point in time

4 Assessment of the options

The paper Beyond 2011: Narrowing down the Options (O3, 2013) provides an overview of the different options considered and how they were narrowed down to the two census approaches included in the consultation:

- once a decade, like that conducted in 2011, but primarily online
- using existing government data and compulsory annual surveys

Both approaches would provide statistics about the size of the population, nationally and for local authorities. A census using existing administrative data and surveys would provide more statistics about the characteristics of the population every year, while an online census would provide more detailed statistics once a decade.

These options have been assessed against the criteria set out in section 3. Sections 4.1 to 4.6 present the evidence against the user requirements, while section 4.7 covers the constraints.

Throughout this assessment we have assumed that an online census once a decade would be designed to deliver data of an equivalent quality to that achieved in the 2011 Census, and that ONS experience of census delivery could be drawn upon to overcome the associated technical and methodological challenges.

4.1 Assessment of user requirement criteria at a glance

Figure 3 presents an overview of the RAG statuses for the two census approaches against the evaluation criteria for user requirements. The supporting evidence is discussed in more detail in sections 4.2 to 4.6.

In the previous assessment there was insufficient evidence to make an assessment against the genealogical and historical study criterion for a census using administrative data and surveys and was therefore rated blue. In this assessment, an amber/red status has been assigned against this criterion for this option. There were no other changes in RAG status against user requirement criteria in this round of assessment.

Figure 3: Options at a glance – user requirement criteria[4]

The relevant sections of this table are repeated below with the supporting discussion.

Criterion category	Criterion statement	Online census once a decade		Census using administrative data and surveys	
		Current assessment	Previous assessment	Current assessment	Previous assessment
Statistical quality – population estimates	P1 – Current maximum quality every year	N/A	N/A	Amber	Amber
	P2 – Current quality with peak and decline	Green	Green	N/A	N/A
	P3 – Current average quality in every year	N/A	N/A	Amber	Amber
Statistical quality – population characteristics	A1 – minimum quality standard	Green	Green	Green	Green
	A2 – Greater frequency	Red	Red	Green / Amber	Green / Amber
	A3 – Greater detail	Green	Green	Red	Red
Microdata	Allows for the production and utilisation of record level anonymous microdata outputs	Green	Green	Green / Amber	Green / Amber
Longitudinal survey	Allows for the continuation of the LS in its current form	Green	Green	Amber	Amber
Genealogical and Historical study	Will make available the information required to support historical (including genealogical) research	Green	Green	Amber / Red	Blue

[4] An online census once a decade is designed to deliver population estimates from a high quality benchmark (e.g. a census) periodically, with declining quality until a further benchmark is available and has been assessed against the variable quality criterion P2. A census using administrative data is designed to deliver population estimates to a consistent level of quality every year and has been assessed against the maximum quality P1 and average quality P3 standards.

4.2 Evaluating the quality of population estimates

The two census approaches being assessed reflect two different approaches to population estimation.

- An online census once a decade would use the cohort component method[5] to estimate the population between censuses, with increasing use of administrative data
- A census using administrative data and surveys would use administrative data already held by government with a coverage survey to produce an annual estimate of the population in local areas

The local authority and national quality standards are presented in Appendix A. The assessment against these quality standards is summarised in Table 4 and discussed in more detail below.

Table 4: Summary of ratings against statistical quality criteria for population estimates

Criterion category	Criterion statement	Online census once a decade	Census using administrative data and surveys
Statistical quality – population estimates	P1 – Current maximum quality every year	N/A	AMBER
	P2 – Current quality with peak and decline	GREEN	N/A
	P3 – Current average quality in every year	N/A	AMBER

4.2.1 Online census once a decade

An online census once a decade meets quality standard P2 – the quality achieved in the current system (with a peak in each census year and then a decline between censuses). The quantitative standards for P2 presented in Appendix A are based on the quality achieved in the 2011 Census (for the peak year) and the 2010 mid-year population estimates (for year nine). We have assumed that an online census in 2021, in combination with the current population estimates methodology, would be designed to continue to meet the standard for P2.

Quality standards P1 and P3 relate to population estimates achieving a consistent level of quality over the whole 10 year period, so are less relevant to the design of an online census once a decade and ratings have therefore not been provided against these standards.

4.2.2 Census using administrative data and surveys

Our research to date shows that it might be possible to produce population estimates through annual linkage of administrative data to meet quality standard P3 (average), and potentially in the longer term, quality standard P1(maximum), but further development of methods and research is

[5] ONS produces mid-year population estimates using the cohort component method. Further information can be found here: http://www.ons.gov.uk/ons/guide-method/method-quality/quality/quality-information/population/methods-guide-for-mid-2012-population-estimates.pdf

required to confirm this. A benefit of a census using administrative data to produce population estimates is that it could be designed to deliver consistent quality every year.

This approach has been assessed through comparing results produced using administrative data with the 2011 Census estimates, and their performance against the relevant quality standards set out in Appendix A. Results at the national and local authority (LA) level against the maximum and average quality standards of the best performing administrative data-based approach were reported in Beyond 2011 Options Report 2 (Paper O2). Paper M6 provides an overview of the administrative data-based approach for producing population estimates.

The results assessed here are based solely on administrative data and do not use an estimation process based on a coverage survey. An estimation process would be used to bring together the administrative data with the proposed population coverage survey to further improve the national and sub-local authority population totals. Quality standards for sub-local authority population estimates have not been set but initial estimates from the best performing administrative data model have been produced. Further information is available in Beyond 2011 Statistical Research Update, Paper M13.

Table 5 shows the results against the maximum and average quality standards for LA population estimates by age and sex group of the best performing administrative data-based model. This model shows that results for 89.3 per cent of local authorities were within ±7.2 per cent of 2011 Census estimates (standard P1) and 97.3 per cent were within ±12.5 per cent (standard P3). This approach meets the average quality standard P3 for LA population estimates by quinary age and sex group.

Table 5 Administrative data model performance against the LA quality standards for population estimates by 5 year age and sex group

Quality Standard	97 % of population estimates by quinary age and sex group (produced annually at the LA level) have a 95 % confidence interval of …	Proportion of LA/age/sex groups within quality standard compared with 2011 Census estimates (%)
P1 (maximum)	± 7.2 % or better	89.3
P3 (average)	± 12.5 % or better	97.3

However, considering how the results compare with the LA and national total population quality standards, as presented in the second Options Report (O2) in July 2013, the model systematically underestimates the population. We have been undertaking research on two approaches to coverage adjustment and estimation (Beyond 2011 Statistical Research Update, Paper M13), but further research is required to determine the quality that could be achieved using these methods.

Bias

In addition to meeting these quality standards for accuracy there is a requirement to understand the bias and variability in population estimates. Simulation studies described in Beyond 2011 Statistical Research Update (Paper M13, published at the same time as this paper) have focused on two estimation approaches; Dual System Estimation (DSE) and the weighting class method.

The DSE estimation method performed similarly to findings reported in Paper M8, suggesting this approach looks promising and shows that quality standards are likely to be met. However, DSE is prone to a positive bias as a result of matching error and erroneous inclusions (Paper M13).

The results for the weighting class method showed that this approach is prone to some negative bias, largely relating to non-response in a coverage survey of individuals within a responding household. It also has issues when the class sizes are small, leading to unstable estimates, but is less susceptible to differing levels of over-coverage. Further information is available in Paper M13.

At this point it is difficult to make a fair comparison between a DSE based approach and a weighting class approach. Our understanding of DSE and methods to make adjustments to address biases is much more advanced and further research would be required to understand the weighting-class approach and how the biases could be rectified or an adjustment made.

4.3 Evaluating the quality of population characteristics

The two census approaches assessed reflect two different approaches to collecting information about the characteristics of the population:

- An online census once a decade would collect detailed information every 10 years on a wide range of topics and a range of geographic levels
- An annual compulsory survey of 4 per cent of households per year - would provide less detailed information, but every year

The population characteristics quality standards set out in Appendix A combine geography, frequency and accuracy. Table 6 summarises how each of the options was rated against all the quality standards. In making this assessment it has been assumed that the socio-demographic survey would be mandatory.

Table 6: Summary of ratings against statistical quality criteria for population characteristics

Criterion category	Criterion statement	Online census once a decade	Census using administrative data and surveys
Statistical quality – population characteristics	A1 – Minimum quality standard	GREEN	GREEN
	A2 – Greater frequency	RED	GREEN/ AMBER
	A3 – Greater detail	GREEN	RED

Our research indicates that both approaches could meet the minimum quality standard (A1).

Further research on a census using administrative data and surveys has shown that using a simple random sample approach, there are some characteristics for which it would not meet the greater frequency quality standard (A2) and therefore this approach has been rated green/amber. Further information is available in Beyond 2011: Producing Socio-demographic Statistics 2 (Paper M12).

It is not possible to meet the greater detail quality standard (A3) using a 4 per cent survey as this would not produce estimates of sufficient accuracy at OA level.

One of the key messages from the consultation was that there was continued support for detailed information about small areas and small populations. The reduced precision of outputs from a 4 per cent survey alone would not fully meet this need:

> *'... the reduced precision will mean that there is much reduced ability to distinguish within LA [Local Authority] differences and change over time in small areas ...'*
>
> *Oxford City Council*

> *'... The confidence intervals estimated around small populations... are so large as to render the identification of ethnic inequalities, differences between places and change over time impossible to identify with confidence ...'*
>
> *ESRC Centre on Dynamics of Ethnicity*

4.4 Meeting the user requirement for microdata

Table 7 summarises the ratings against meeting the user requirement for microdata.

Table 7: Summary of ratings against user requirement for microdata

Criterion category	Criterion statement	Online census once a decade	Census using administrative data and surveys
Microdata	Allows for the production and utilisation of record level anonymous microdata outputs	GREEN	GREEN/ AMBER

There is a precedent for the release, with appropriate confidentiality safeguards and under strict conditions of use, of anonymous microdata from both censuses and surveys in the UK, and this is reflected in the green and green/amber ratings assigned to all the options. There are three dimensions to the user requirement:

- the topic range available on the dataset;
- the date or time period that the data relate to;
- the sample size

An online census once a decade provides the opportunity to release anonymous microdata covering a wide topic range and for a large sample of the population for a specific point in time, making analysis straightforward.

A census using administrative data and surveys would allow the release of anonymous microdata covering a wide topic range. Sample data would be available every year, so more frequently than once a decade; however the sample of records that could be released would be limited. Further research would be required to determine whether the complete or restricted sample could be released every year. The collection of data over a period of time would also make understanding the output from the analysis more complex.

4.5 Longitudinal study

Table 8 summarises the ratings against meeting the user requirement for longitudinal analysis.

Table 8: Summary of ratings against user requirement for longitudinal analysis

Criterion category	Criterion statement	Online census once a decade	Census using administrative data and surveys
Longitudinal Study	Allows for the continuation of the LS in its current and/or a new form	GREEN	AMBER

The current Longitudinal Study (LS) brings together information on a wide range of topics from the 1971 to 2011 Censuses with births, deaths, cancer data and information from NHS patient registration systems throughout that period for approximately 1 per cent of the population. The LS allows analysis of population and health outcomes linked to other population characteristics. It is a key source in the production of life expectancy by social class and also used in a number of health studies. The LS is also used as a tool in census quality assurance. It is the availability of linked data covering a long period of time combined with regular snapshots (from the 10-yearly census) on a wide range of topics that users value the most in the current LS model.

The online census would allow the current LS to continue, and potentially be enhanced by adding more data sources in the future.

Users would like to see further administrative data sources linked into the LS to extend the richness of the resource. A census using administrative data and surveys would enable the existing LS to remain in place, and could be extended through continuing to add in the administrative data sources that already form part of the LS. Alternatively there could be potential for a new LS to be started.

However, a census using administrative data and surveys could reduce the information available for existing LS members and reduce the scope for record level and population subgroup analyses if additional information from administrative sources was not available. Users would also prefer characteristics information based on a single point in time (if it is of sufficient sample size) as it easier for them to analyse and interpret.

4.6 Genealogical and historical record

Table 9 summarises the ratings against the user requirement for genealogical and historical data.

Table 9: Summary of ratings against user requirement for genealogical and historical data

Criterion category	Criterion statement	Online census once a decade	Census using administrative data and surveys
Genealogical and historical study	Will make available the information required to support historical (including genealogical) research	GREEN	AMBER/ RED

An online census once a decade would allow the creation of a historical record that could be made available after 100 years, for genealogical and historical research in the future.

In the previous assessment there was insufficient evidence to make an assessment against the genealogical and historical study criterion for a census using administrative data and surveys and it was therefore rated blue.

Since then, users, through consultation, have stressed the importance of a census to family researchers as an entire snapshot of the population and many consider a census in the current system as invaluable and irreplaceable (ONS 2014). In response to the consultation, most users accepted that an online census once a decade could provide the information required for genealogists to continue to use as a source of information in the future. Many family historians did not support a census using administrative data and surveys because they did not think it offered sufficient information for future historians. However, others could see potential opportunities for the use of administrative data if it was available alongside information collected through an online census once a decade.

ONS has worked with The National Archive, historical researchers and genealogists to discuss the options for provision of a historical record from a census using administrative data and surveys but further research would be required to develop these options. This is reflected in the amber/red rating for this approach.

4.7 Assessment of constraints at a glance

Figure 4 presents an overview of the ratings for each of the options against the constraints identified in section 3. The options have been rated against the environmental impact and compliance with the code of practice criteria for the first time in this assessment.

Since the previous assessment, ratings against the equality impact criterion have changed from green to green/amber for the online census once a decade, and from amber to amber/red for a census using administrative data and surveys.

Figure 4: Options at a glance – constraints

Criterion category	Criterion statement	Online census once a decade		Census using administrative data and surveys	
		Current assessment	Previous assessment	Current assessment	Previous assessment
Legal	Allows for production of information at the geographic levels specified in Regulation (EC) No 1201/2009	Green	Green	Green	Green
	Powers are, or will be, in place to lawfully implement the option	Green	Green	Amber / Red	Amber / Red
Technical and statistical feasibility	System could be built and operated in the required timeframes	Green	Green	Amber	Amber
	Full development of the statistical methodology is achievable within the required timeframes	Green	Green	Amber	Amber
Data sources	Required data is accessible	Green	Green	Amber	Amber
	Solution is robust to changes in datasets	Green	Green	Amber	Amber
Impact assessments	Allows for the collection, use and production of statistics with no privacy concerns	Green / Amber	Green / Amber	Green / Amber	Green / Amber
	Allows for the collection, use and production of statistics and related outputs with no equality concerns	Green / Amber	Green	Amber / Red	Amber
	Allows for the collection, use and production of statistics and related outputs with no environmental concerns	Amber	Blue	Amber	Blue
Public acceptability	Allows for the collection, use and production of statistics and related outputs with limited burden on the public	Amber	Amber	Green / Amber	Green / Amber
	There is broad public acceptance of the option	Amber	Amber	Amber	Amber
Compliance with Code of Practice	The extent to which the option is (or could be) compliant with the Code of Practice for Official Statistics	Green	N/A	Amber	N/A

4.7.1 EU legislative requirements

Table 10: Summary of ratings against EU legislative requirements

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Legal	Allows for production of information at the geographic levels specified in Regulation (EC) No 1201/2009	GREEN	GREEN

The EU sets legislative requirements for member states to provide statistics based on a census every ten years. For the purposes of this assessment, the regulation relating to the last round of censuses has been used (Regulation (EC) No 1201/2009). The assessment reflects the fact that both options could be designed to meet these requirements.

4.7.2 Legal framework

Table 11: Summary of ratings against legal framework

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Legal	Powers are, or will be, in place to lawfully implement the option	GREEN	AMBER/ RED

An online census once a decade has been rated green against the legal framework criterion as it could be implemented using powers within the Census Act 1920. Secondary legislation would be required in the form of a Census Order and Census Regulations, but this is a proven process.

A census using administrative data and surveys has been rated as amber/red due to the need for additional data sharing legislation to ensure the continued availability of administrative data. In addition, new legislation would be required to support the implementation of compulsory surveys.

4.7.3 Technical feasibility

Table 12: Summary of ratings against technical feasibility

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Technical and statistical feasibility	System could be built and operated in the required timeframes	GREEN	AMBER

ONS successfully delivered large scale, short duration services in support of the 2011 Census, and this is expected to be achievable for an online census in 2021.

The amber status assigned to a census using administrative data and surveys reflects the challenge of developing services to link and process large quantities of administrative data. And ONS is less experienced in sourcing long term well supported operational systems of the scale and nature required to support an ongoing survey of 4 per cent of the population.

4.7.4 Statistical feasibility

This criterion considers the feasibility of developing and delivering a robust statistical methodology within the timeframe required for the next census.

In this context an amber rating indicated that some issues need to be resolved, or that the approach uses some untried techniques, but evidence suggests that they could be implemented within the required timeframe. A red rating would indicate that there was no prospect of fully developing the required statistical methodology within the required timeframe.

Table 13: Summary of ratings against statistical feasibility

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Technical and statistical feasibility	Full development of the statistical methodology is achievable within the required timeframes	GREEN	AMBER[6]

ONS has experience of developing census and survey methodology, giving a green rating against the risk associated with developing the required statistical methodology for an online census once a decade. The survey element of the census using administrative data and surveys is therefore also rated green.

ONS has not previously implemented an estimation process based on administrative data in conjunction with a coverage survey. Significant progress has been made in this area (Paper M13) but as the Independent Review of Methodology concluded, additional evidence and further methodological development would be required to provide a methodologically sound basis for implementing this option. This option has therefore been given an amber rating.

4.7.5 Data sources – accessibility

Table 14: Summary of ratings against accessibility of data sources

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Data sources	Required data is accessible	GREEN	AMBER

[6] It is recognised that responses to the public consultation from September – December 2013 make it clear that there is an ongoing demand for detailed information about small areas and small population groups currently provided by the decennial census. A census using administrative data and surveys would not be able to provide this data. The assessment of the approaches against this criterion relate to the feasibility of developing and delivering methods and not the outputs that each approach would provide.

An online census once a decade and current mid-year estimates methodology are dependent on data from the census and record-level data from administrative sources.

Access to administrative data needed to support the current mid-year population estimates methodology is under the provision of the Statistics and Registration Service Act 2007 (SRSA; UK Parliament, 2007) or through existing legal gateways[7], secondary legislation and source specific data sharing agreements. Therefore, as data access arrangements are in place, the online census once a decade is rated green.

These existing data access arrangements provide access to those sources required for a census using administrative data and surveys for research purposes. Further data sharing legislation would be required to ensure ongoing access to existing sources and to gain access to new sources created after the SRSA came onto the statute book. A census using administrative data and surveys has been given an amber rating reflecting the greater risk associated with the ongoing provision of data associated with this approach.

4.7.6 Data sources – resilience

Table 15: Summary of ratings against resilience to changes in data sources

This criterion relates to the influence of ONS, over datasets which the solution is dependent on. In this context, a green rating indicates that the solution is dependent on datasets over which ONS has good influence, or the methodology has been proved to be robust to changes in the quality of the data. An amber rating indicates that the solution is dependent on datasets over which ONS has varying degrees of influence, with a red rating indicating ONS has little or no influence.

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Data sources	Solution is robust to changes in datasets	GREEN	AMBER

Access to online census data once a decade is predominantly within ONS's control whilst the current population estimates methodology is dependent upon record level administrative data sources[8] to calculate internal migration. This approach has been given a green rating as the data sources used are relatively stable.

A census using administrative data and surveys carries greater risk due to the greater dependence on administrative sources, without an independent benchmark from a once a decade census. Additionally the sensitivity of the method to changes in datasets cannot yet be tested. As a result this approach has been given an amber rating.

[7] Statistics and Registration Service Act 2007 (Disclosure of Higher Education Student Information) Regulations 2009
Statistics and Registration Service Act 2007 (Disclosure of Pupil Information)(England) Regulations 2009
Statistics and Registration Service Act 2007 (Disclosure of Pupil Information by Welsh Ministers) Regulations 2011
Statistics and Registration Service Act 2007 (Disclosure of Social Security and Revenue Information)Regulations 2012

[8] The record level administrative sources used to calculate internal migration are the Patient Register and data from the Higher Education Statistics Agency.

4.7.7 Privacy impact

Table 16: Summary of ratings against privacy impact

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Impact assessments	Allows for the collection, use and production of statistics with no privacy concerns	GREEN/ AMBER	GREEN/ AMBER

There are potential privacy concerns with both census approaches. ONS can draw on its experience of undertaking censuses and surveys to demonstrate that all necessary measures, to safeguard confidentiality and comply with legal obligations, would be taken. ONS also has experience of putting in place the measures necessary to protect privacy when using administrative data in the current population estimates process, and in the research phase of the Beyond 2011 Programme (Beyond 2011 Safeguarding Data for our Research: Our Policy, Paper M10, July 2013).

This was recognised in the Information Commissioner's Office response to the public consultation from September – December 2013:

> *'The Commissioner has confidence in the ONS' approach to data protection as demonstrated by previous censuses, the work it has already done as demonstrated by the findings of the '2011 Census Security: Final Report of the Census Offices' and the 'Safeguarding Data' paper and associated documents. Therefore the Commissioner's view is that, although there are data protection risks associated with either proposed method of collecting the census, the ONS is well placed to be able to address data protection issues by identifying the risks and taking steps to mitigate those risks.'*
>
> *Information Commissioner's Office*

However, greater use of administrative data does cause concern for some groups of people – see Public Attitudes report . We are continuing to consult with privacy groups in order to ensure that any potential privacy issues are identified.

4.7.8 Equality impact

Table 17: Summary of ratings against equality impact

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Impact assessments	Allows for the collection, use and production of statistics and related outputs with no equality concerns	GREEN/ AMBER	AMBER/ RED

The Public Sector Equality Duty applies to both approaches to collecting census data, as highlighted in the Equality and Human Rights Commission response to the public consultation:

'The Public Sector Equality Duty.... requires all public authorities to publish information showing compliance with the Equality Duty... For both the Commission and other public authorities, the Census provides a population-wide coverage and detailed analysis is not available from other sources'

Equality and Human Rights Commission

ONS will draw upon its experience of conducting censuses and surveys to ensure that our approach will comply with all relevant equality obligations. However, the Beyond 2011 Equality Advisory Group and other equality and diversity organisations have raised concerns relating to digital exclusion for both approaches. It will be important to ensure that specific groups who, for example, may not have access to the internet, can participate effectively and comprehensively. This has been reflected in the revised rating of the online census approach to green/amber.

The survey design and sampling strategy in a census using administrative data and surveys would be developed to minimise any negative impact on specific groups. However, numerous groups raised concerns in the public consultation about the loss of detailed multivariate information for small population groups. In addition, they have raised concerns about potential under-coverage of specific groups, including 'invisible communities' and those living in communal establishments. The rating for a census using administrative data and surveys has therefore been revised to amber/red.

4.7.9 Environmental impact

Table 18: Summary of ratings against environmental impact

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Impact Assessments	Allows for the collection, use and production of statistics and related outputs with no environmental concerns	AMBER	AMBER

Statistical options have not been previously assessed against this criterion, but an initial consideration has resulted in both census approaches being rated amber.

The assessment has been based on consideration of paper consumption and travel requirements for field staff. Under current working assumptions an online census once a decade would need to make provision for up to 25 per cent of responses through paper questionnaires. This would be significantly less than the current paper-based census system, but is likely to be greater than the paper requirement for a census using administrative data and surveys.

The travel requirements for any field force will depend on the geographic clustering of the required field visits for field staff and the period of data collection. Spreading data collection over a 10 year period or larger geographic area would increase the amount of travel required, but reducing the sample size (that is, in sampling 40 per cent of the population over 10 years) could partially offset this. Further research would be required to determine the travel requirements of each option and how they compare.

For any individual year the environmental impact of a census using administrative data would likely be less than that of an online census once a decade. However, there is insufficient evidence at present to predict whether over a ten year period it would have more or less of an environmental impact than on online census once a decade.

4.7.10 Public acceptability – burden

Table 19: Summary of ratings against burden on the public

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Public acceptability	Allows for the collection, use and production of statistics and related outputs with limited burden on the public	AMBER	GREEN/ AMBER

The burden associated with each of the options has been interpreted in relation to whether it places a greater burden on the public than the 2011 Census (red), a similar burden (amber) or a lesser burden (green). The burden has been based on a combination of the total burden across the population of providing the information required and the number of times individuals may be contacted to provide information over a decade.

In an online census once a decade, every household and person in a communal establishment would be required to complete a census form across a 10 year period, with 1 per cent of the population requested to participate in a coverage survey. This represents a similar burden to the 2011 Census and has been rated amber.

A census using administrative data and surveys would, overall, place a smaller burden on the public. This approach would require two annual surveys of 1 and 4 per cent of the population respectively. Therefore, 50 per cent of the population would be required to participate in survey over a 10 year period. There is potential for individuals to be contacted on multiple occasions throughout this period but ONS would seek to minimise this. This approach has therefore been rated green/amber.

4.7.11 Public acceptability – perception

Table 20: Summary of ratings against public perception

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Public acceptability	There is broad public acceptance of the option	AMBER	AMBER

We have carried out research into public attitudes to the collection and use of data for production of official statistics and research, including different potential approaches for producing population statistics. This research was undertaken over the period 2009-2013 and included original quantitative and qualitative research undertaken by ONS, as well as research commissioned by ONS and undertaken by Ipsos MORI. This research was published in March 2014.

ONS also undertook an extensive review of literature from a range of sources including reports produced by government departments, national statistics institutes, academic organisations, think tanks, commercial research organisations and the media.

In summary, this research demonstrated that:

- there is generally a very low level of public understanding about data, how it is collected and used, and only basic knowledge of the related vocabulary
- the public generally does not understand the difference between operational and statistical uses of personal data
- nearly half of the public assume that government already routinely links data about the population from multiple sources in a central data store
- around three quarters of people do not object to data held by other government departments being shared with ONS
- the public are supportive of data sharing when personal or public benefit can be demonstrated and these are communicated effectively
- data linking and storage is more acceptable if the personal data are anonymised, however, explaining the process of anonymisation is complex and difficult for the public to understand
- any objections to the use of personal data are largely related to security and privacy concerns
- the public get most of their messages about the use of personal data from the media and their own personal experiences
- around three quarters of the public trust ONS to protect the confidentiality of their data;
- the public is generally positive towards the decennial census as a means of gathering information about the population
- when provided with reassurance with regard to security and privacy, the public broadly support ONS re-using administrative data to produce statistics.

The public's views of the acceptability of the use of personal data for statistical and research purposes differ according to who is using the data and for what purpose. While three quarters of the public do not object to data being shared with ONS, around three quarters raised concerns about data sharing in general. These concerns encompass:

- security and confidentiality
- privacy and anonymity
- transparency, control, consent and trust
- governance and regulation
- public and personal benefits.

Public acceptability of the use of data is improved by:

- appropriate communications, in particular, knowing to what use the data will be put and what benefits will result; and
- ensuring that safeguards relating to security and privacy are in place and communicated effectively.

This research has shown that public views are not static and will continue to evolve in the light of public information and debate. Taking all of this research into account, both approaches have been rated amber, which in this context means that there are some public concerns, but these are not sufficient to present a significant risk to the integrity of the statistical system.

4.7.12 Compliance with the Code of Practice for Official Statistics

Table 21 shows the assessment of the two approaches against the new criterion relating to compliance with the Code of Practice for Official Statistics, as detailed in section 4.3.

Table 21: Summary of ratings against compliance with the code of practice for official statistics

Criterion category	Criterion statement	Online census once a decade	A census using administrative data and surveys
Compliance with Code of Practice	The extent to which the option is (or could be) compliant with the Code of Practice for Official Statistics	GREEN	AMBER

The 2011 Census was assessed by the UK Statistics Authority as compliant with the Code of Practice for Official Statistics through a series of special assessments and statistics from the 2011 Census were consequently designated National Statistics. ONS has experience of planning and implementing a census to produce statistics that are compliant with the Code of Practice. The risk associated with an online census once a decade has therefore been rated green.

Compliance with the Code of Practice requires, amongst other things, understanding and explanation of quality and understanding of any discontinuity in statistics that may result from a change in methods. Moving to a census using administrative data and surveys without a 2021 online census carries a risk of not understanding any such discontinuity. The risk relating to this approach has therefore been given an amber rating.

5 Summary and Conclusions

This assessment has brought together all the evidence gathered during the Beyond 2011 Programme's research, including feedback from the public consultation and the Independent Methodological Review. It has included the first assessment of:

- population estimates by five year age and sex groups against quality standards at local and national levels (Table 5)
- the risk associated with compliance with the Code of Practice for Official Statistics
- the environmental impact of the two approaches assessed.

The use of quality standards and evaluation criteria has enabled systematic assessment of what each of the two census approaches could deliver and identification of where the risks would lie in implementing either of them.

5.1 Estimating the population

The quality standards for population estimates have been set in relation to what is achieved in the current system. It is assumed that an online census once a decade could continue to meet this standard (P2, variable quality over time) in the future.

The benefit of a census using administrative data and surveys is that it could be designed to deliver consistent quality every year. There has been significant progress in the research phase of the Programme in developing methods to produce population estimates from administrative data, but the Independent Review of Methodology found that there was not sufficient evidence to conclude that this approach provides a methodologically sound basis for replacing 2011 Census methodology at present.

5.1.1 Estimating population characteristics

Our research has shown that both approaches could meet the minimum quality standard (A1), but the two census approaches included in this assessment represent a trade-off between delivering more detailed data once a decade, or more frequent data for larger geographic areas.

A key message from the public consultation run from September to December 2013 was that statistics for small geographic areas and small populations are regarded as essential to local decision making, policy making and diversity monitoring in fulfilment of the legally binding Public Sector Equality Duty (ONS 2014). It is not possible to meet the greater detail quality standard (A3) using a 4 per cent survey in a census using administrative data, as it would not produce estimates of sufficient accuracy at the smallest geographic level (OA). Further research on, and increased access to, administrative data on population characteristics in combination with a 4 per cent survey would be needed to help produce more accurate small area statistics.

5.1.2 Other outputs and constraints

There are a number of other outputs currently produced using census data including anonymised microdata, the ONS Longitudinal Study and a genealogical and historical record. An online census once a decade would enable provision of these outputs in their current form. Further research would be required to fully understand alternative provisions from a census using administrative data and surveys and the impact on these outputs.

Since the last options assessment in July 2013 (Beyond 2011 Options Report 2, Paper O2, July 2013) the assessment of risks relating to equality requirements have increased for both approaches. Digital exclusion and participation of 'invisible' communities are the key additional concerns for an online census once a decade. For a census using administrative data and surveys there are additional concerns about the provision of detailed statistics for small population groups and geographic areas and the coverage of communal establishments to enable users to comply with their Public Sector Equality Duty.

The risks associated with a census using administrative data and surveys are currently greater than those for an online census once a decade. A key constraint is the legislative framework. An online census once a decade could be implemented using existing legislation, whereas additional legislation would be required for a census using administrative data and surveys to:

- to underpin the supply of administrative data
- to make surveys mandatory.

There is also greater risk associated with a census using administrative data and surveys in complying with the Code of Practice for Official Statistics compared with the existing, compliant census methods. Further research would be required to develop methods for quality assurance, quality measurement and to understand the impact of methodological change.

5.2 Conclusion

This fourth and final assessment of the statistical options against the quality standards and evaluation criteria has shown that there is greater risk to future production of population statistics associated with a census using administrative data and surveys compared with an online census once a decade approach.

The Independent Review of Methodology had no hesitation in saying that an online census represented '*a methodologically sound basis for replacing Census 2011'*; they were not prepared to say the same for the administrative data option at the current stage of development in England and Wales.

An online census once a decade could continue to produce population estimates and statistics about population characteristics that meet user requirements for statistics at the smallest geographic levels, and for small population groups. However, there remain a range of methodological challenges requiring further research before statistics from a census using administrative data approach could meet user needs. The risks relating to the constraints of legislative requirements and compliance with the Code of Practice for Official Statistics are also greater for this approach compared to an online census once a decade.

The National Statistician's Recommendation published in March 2014 proposed making best use of all sources, increasing the use of administrative data and surveys to enhance statistics from the 2021 Census and improve statistics between censuses.

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Appendix A: Beyond 2011 Quantitative Design Standards

A1 Introduction

This annex describes the research undertaken to develop the quality standards used throughout the options report as well as the standards themselves. Sections A2 – A3 describe the approaches and standards for population estimates and characteristics respectively. Section A4 presents the conclusions.

A2 Quality standards for population estimates

This section explains how the quality standards for population estimates were set. The standards were designed to reflect the quality achieved in the current population estimates system, including the census and mid-year population estimates. There are three quality standards as shown in table A1 below.

Table A1: Theoretical quality standards for population estimates

	Quality standard
P1 (Maximum)	Maximum quality achieved in the current system (ie. what is achieved in a census year), every year
P2 (Variable)	The quality achieved in the current system (with a peak and then a decline during the decade)
P3 (Average)	The average quality achieved in the current system, every year

To set these quality standards three different levels of accuracy are required:

- the peak level of accuracy in the current system (links to P1 and P2)
- the average accuracy over a decade in the current system, this is taken as the mid-point in the decade (links to P3)
- the minimum level of accuracy in the current system, taken as the end-point in the decade, just before the next census (links to P2)

In all of these cases our quality standards were based upon our best estimates of the quality obtained under the existing census system. Box 1 explains and gives an example of a confidence interval.

In addition to the accuracy requirement within each standard the quality dimensions of geography and frequency were also addressed, by stating the level of geographic detail and the frequency with which that accuracy should be achieved.

Box 1: What is a confidence interval?

Confidence interval – A confidence interval is a statistical measure of how much uncertainty there is about an estimate. The narrower the confidence interval the lower the uncertainty. For a 95 % confidence interval the true (unknown) value of the estimate would be expected to lie within it 19 times out of 20.

In tables 1 and 2 the confidence intervals are expressed as a percentage of the estimate.

For example, for an average LA with a true (unknown) population of 150,000 people a 95% confidence interval of ± 3.0% would be calculated as follows:

Lower limit = 150,000 – (3% of 150,000) = 150,000 – 4,500 = 145,500

Upper limit = 150,000 + (3% of 150,000) = 150,000 + 4,500 = 154,500

This gives a confidence interval of 145,500 to 154,500

A2.1 Peak level of accuracy

One of the objectives agreed for the 2011 Census was "To provide the most accurate possible census population estimates for different geographic areas across England and Wales." (ONS, 2010). Within this objective there were two quality aims, one relating to local authorities, the other relating to England and Wales as a whole. They were:

- All local authority population estimates have a 95% confidence interval of ± 3% or better
- The national population estimate has a 95% confidence interval of ± 0.2%

At local authority level the following was achieved for the 2011 Census:

- 97 per cent of local authority population estimates had a 95% confidence interval of ±3% or better (ONS, 2012a)

This standard was therefore adopted as an indicative quantitative measure for P1, to reflect the maximum accuracy in the current system at local authority level. If an option proposed within the Beyond 2011 Programme meets this standard then it would be able to produce population estimates that are of similar quality to those produced from the 2011 Census.

It is also important to consider the quality of those local authorities whose annual population estimate was not within the standard above, so an additional standard was needed.

The following was actually achieved for the 2011 Census:

- All local authority population estimates had a 95% confidence interval of ±3.8% or better

This standard was therefore also adopted as an additional quantitative measure for P1, to reflect the maximum accuracy in the current system at local authority level.

The 2011 Census also had the following accuracy standard for the national population estimate (ONS 2010):

- The national population estimate has a 95% confidence interval ±0.2% or better

This standard was exceeded in the 2011 Census:

- The national population estimate had a 95% confidence interval ±0.15% (plus or minus 83,000 people) (ONS, 2012a).

This standard was therefore adopted as a quantitative measure for P1, to reflect the maximum accuracy in the current system at the national level. Note that national refers to England and Wales. The equivalent standards for England and Wales separately (based on 2011 Census results) were:

- The national population estimate for England had a 95% confidence interval ±0.15%
- The national population estimate for Wales had a 95% confidence interval ±0.64%

The accuracy achieved for the population estimate for Wales is less than that for England since we are estimating for a smaller population.

A2.2 Minimum accuracy

This standard needed to reflect the minimum level of accuracy of population estimates in the current system. This will be the accuracy of the mid-year population estimates at the end of the decade, just before the next census is taken. The 'Measuring Uncertainty Project' (ONS, 2012c) recently published statistical measures of uncertainty for every LA mid-year population estimate from 2002-2010 derived from a simulation process. Although these are neither national nor experimental statistics and the methodology used to produce the estimates is in its infancy (and at present only incorporates variability from key sources) these are the only indicators of the level of uncertainty associated with mid-year population estimates. Empirical estimates of variance and therefore 95% confidence intervals were provided for all local authorities in 2010[9]. The results show that:

- 97 per cent of local authority population estimates had a 95% confidence interval of ±6.0% or better, and
- All local authority population estimates had a 95% confidence interval of ±13% or better (excluding outliers[10])

The simulation approach can also be used to provide indicators of the level of uncertainty at the national level for the mid-year population estimate. The results show that in 2010:

- The national population estimate for England and Wales had a 95 % confidence interval ±0.27%
- The national population estimate for England had a 95% confidence interval ±0.28%
- The national population estimate for Wales had a 95%t confidence interval ±1.06%

These standards were therefore also adopted as quantitative measures for P2.

[9] The complete set of confidence intervals can be downloaded from http://www.ons.gov.uk/ons/guide-method/method-quality/imps/latest-news/uncertainty-in-la-mypes/index.html

[10] Outliers are Isles of Scilly and City of London, both of which have very small populations.

A2.3 Accuracy at the mid-point in the decade

This standard reflects the 'average' accuracy of population estimates in the current system. This will be the accuracy of the mid-year population estimates in the middle of the decade, 2006. Note, although the mid-point has been used to represent the average accuracy it is recognised that the impact of changes in the make up of the EU in 2004[11] and again in 2007[12] may have caused 2006 estimates to be less representative of the average across the decade.

The Measuring Uncertainty Project results (ONS, 2012c) can also be used to consider confidence intervals for 2006 mid-year population estimates. Results for 2006[17] show that overall:

- 97 per cent of local authority population estimates had a 95% confidence interval of ±5.2% or better, and
- All local authority population estimates had a 95% confidence interval of ±8.5% or better (excluding outliers[18])

So if an option proposed within the Beyond 2011 Programme meets these quality standards then it would be able to produce population estimates that are of similar quality to those produced on average in the current system, ie. in the middle of the decade.

The simulation approach can also be used to provide indicators of the level of uncertainty at the national level for the mid-year population estimate. The results show that in 2006:

- The national population estimate for England and Wales had a 95% confidence interval ±0.22%
- The national population estimate for England had a 95% confidence interval ±0.23%
- The national population estimate for Wales had a 95% confidence interval ±0.81%

These standards were therefore also adopted as quantitative measures for P3.

A2.4 Standards for estimates by age and sex

There was a requirement to set quantitative quality standards for population estimates for age and sex groups at the national and local authority level. Quinary age groups were used to ensure consistency with 2011 Census results and considered the practical use of the quality standards, but future research could consider different age groupings.

A2.4.1 Peak level of accuracy

The approach used for setting quality standards for estimates by age and sex was the same as used for total population estimates as described in section A2.1. The standards were based on the quality achieved for the 2011 Census.

[11] In 2004 Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia joined the European Union
[12] In 2007 Bulgaria and Romania joined the European Union.

National estimates by age and sex

The following was achieved for the 2011 Census for 97 per cent of national estimates by quinary age group and sex:

- England and Wales had a 95% confidence interval of ±0.6%
- England had a 95% confidence interval of ±0.6%
- Wales had a 95% confidence interval of ±2.7%

There are only 34 different quinary age and sex groups at the national level. The difference between a '97 % standard' and 'all' becomes minimal and therefore only '97% standards' were reported. It would be possible to set individual standards for each quinary age sex group but this would have over complicated the assessment process and were not set.

LA population estimates by age and sex

For the 2011 Census LA population estimates by quinary age group and sex:

- 97 per cent of estimates had a 95% confidence interval of ±7.2% or better

This standard was adopted as an indicative quantitative measure for P1 to reflect the maximum accuracy in the current system at LA level for population estimates by quinary age group and sex.

Here we have only used the '97% LA standard because of the greater effect outliers would have had in setting a standard for all LAs, it would have created unacceptably wide standards. In assessing the performance against the standards we would continue to analyse estimates produced for all LAs to ensure that those estimates that do not currently meet the standard are not of unacceptable quality.

A2.4.2 Minimum accuracy and accuracy at the mid-point of the decade

The standards for total population estimates were set using statistical measures from the 'Measuring Uncertainty Project' (ONS, 2012c). This simulation approach does not provide measures of uncertainty for national or LA estimates by age and sex and therefore a different approach was required to set standards for population estimates by age and sex for minimum accuracy (P2) and accuracy at the mid-point of the decade (P3).

Statistical measures of uncertainty for mid-year population estimates from 2002-10, derived from the simulation process, indicated that the relationship of the variance of population estimates was linear across time. The linear relationship between the variance over time for total population estimates was assumed to hold for LA estimates by quinary age and sex groups and were then used to extrapolate standards for P2 and P3 based on P1 i.e. the relationship between the standards P1, P2 and P3 at the national and LA level was assumed to hold for P1, P2 and P3 at LA by age and sex, since we know that P1, P2 and P3 can be derived.

It is recognised that this approach is fairly crude and likely to be conservative, but was considered necessary in the absence of any further evidence. The resulting standards are listed below.

The proposed standards for reflecting the minimum level of accuracy of population estimates in the current system (P2) were:

- 97 per cent of LA population estimates by quinary age group and sex had a 95% confidence interval of ±14.4% or better

97 per cent of national estimates by quinary age group and sex:
- England and Wales had a 95% confidence interval of ±1.0%
- England had a 95% confidence interval of ±1.1%
- Wales had a 95% confidence interval of ±4.5%

The proposed standards to reflect the 'average' accuracy of population estimates in the current system (P3; middle of the decade) were:

- 97 per cent of LA population estimates by quinary age group and sex had a 95% confidence interval of ±12.5% or better

97 per cent of national estimates by quinary age group and sex:
- England and Wales had a 95% confidence interval of ±0.8%
- England had a 95% confidence interval of ±0.9%
- Wales had a 95% confidence interval of ±3.4%

A2.4 Bias

The quality standards set out above only reflect the variability of the estimates since census estimates are assumed to be unbiased (that is, they do not systematically under or over estimate the population, or miss specific population sub-groups). The standard for Beyond 2011 also assumed that population estimates are unbiased. Box 2 provides an explanation of bias and how it could affect the quality of population estimates.

Box 2: What is bias?

Bias – When a statistical estimate differs systematically from the 'true' value it is supposed to measure, the estimate is said to be biased.

For example, an administrative register includes everyone who has ever been registered on it. It is possible to remove some people from the register if information about their death or departure from the country has been recorded, but this isn't always the case. It is therefore likely that an estimate from the register will still systematically overestimate the population, and the estimate would be said to be biased.

If the register also excludes certain parts of the population, and no account of this is taken in creating the population estimates this will also introduce bias, as the groups who are excluded would be systematically missed from the estimates.

When estimating the population using a census without any extra adjustment, if there are people who do not respond then the resulting census count will be biased downwards.

No specific standards were set for assessing bias however the level of bias adjustment for the 2011 Census population estimate for England and Wales of 0.5% provides an indication. At the national level 0.5% bias was considered unacceptable and hence was adjusted for in the census. Therefore when evaluating options for Beyond 2011 a bias of 0.5% or greater at the national level was deemed to be unacceptable. At the more local level (estimation area) the smallest bias

adjustment made was 0.4%. This provides another indicator for assessing bias, at the local levels a bias of 0.4% or greater would not be acceptable.

Based on the national level adjustments by age and sex for the 2011 Census (ONS 2012d) a bias of 1.3% or greater for national estimates by age and sex would be considered unacceptable. A bias of 0.4% or greater would be considered unacceptable for total LA population estimates or LA estimates by quinary age sex group.

A2.5 Assessing against the quality standards for population estimates

In the research phase ONS assessed the different census options against the quality standards using two approaches. Results based on an administrative data-based approach were compared to 2011 Census estimates to give an indication of the percentage of local authorities that lie within the ranges specified within the quality standards. These comparisons were an approximation as the 2011 Census estimates themselves were subject to variability. Also the comparisons did not separate variability and bias, but did provide an indication of the accuracy of the trial estimates. Alongside this simulations were used to explore how the variability and bias of the estimates may change under different assumptions, allowing a fuller understanding of the accuracy achievable under alternative options.

In the research phase it was possible to assess bias through simulation. In addition bias could also be assessed though a quality assurance/sense check process (similar to the one adopted for the 2011 Census) comparing estimates to external sources that were not used in the estimation process, undertaking demographic analysis and comparing estimates over time. Bias could be assessed using a similar ongoing quality assurance process in a live operation.

Quality standards were proposed for total population estimates and population estimates for quinary age and sex groups at the national and LA level. There was also a requirement to assess the quality of population estimates for smaller geographies, in particular MSOA and LSOA. Specific standards were not set for these geographies as standards focused on the key outputs for population estimates (which through user consultation) were identified as national and LA population estimates by age and sex. In practice standards set at the LA level can be used to provide an indication of the quality achieved for MSOA/LSOA.

In collaboration with Southampton Statistical Science Research Institute (S3RI) a new methodology has been developed by the ONS to estimate the uncertainty associated with local authority mid-year population estimates (ONS, 2012c). The 'Measuring Uncertainty Project' recently published a research report that included statistical measures of uncertainty for every local authority mid-year population estimate from 2002-2010 derived from a simulation process. Work should be undertaken to continue to develop such approaches and consider how they could be adopted for a Beyond 2011 option. However, it should be noted that the results of the simulation process will only be as good as the assumptions it is based on.

A3 Quantitative Design Standards for Population Characteristics

This section of the appendix describes the proposed quantitative design standards for population characteristics. Table A2 shows the theoretical design standards used as a starting point for the population characteristics.

Table A2: Quality standards for population characteristics

	Geography and frequency	Quality standard (accuracy)
A1	LA and MSOA data once every 10 years	LA statistics for a characteristic applying to 0.2% of the total LA population have a CV of 20% or less MSOA statistics for a characteristic applying to 3% of the total MSOA population have a CV of 20% or less
A2	LA, MSOA and LSOA data annually based on 1 to 5 years of survey data	Exceeding the accuracy standards for A1 plus: LSOA statistics for a characteristic applying to 10% of the total LSOA population have a CV of 20% or less
A3	LA, MSOA, LSOA and OA data once every 10 years	Exceeding the accuracy standards for A1 plus: OA statistics for a characteristic applying to 10% of the total OA population have a CV of 20% or less

The quality levels were expressed in terms of the relationship between the geographical levels, the frequency of update and the accuracy required for a specific population size. The use of a coefficient of variation (CV) of 20 % reflects the quality standards in use for existing National Statistics. Box 3 (overleaf) explains the terminology used in Table A2.

As a starting point the minimum requirements for the accuracy of population characteristics were considered. At a minimum there is a legal requirement for ONS to produce 203 different tables (previously based on census data) at different levels of geography (National/NUTS2/NUTS3/ward[13]) for Eurostat every 10 years. No accuracy targets are stipulated in the regulation, however here it is assumed that 20 % coefficient of variation (CV, or relative standard error) is acceptable since this is the 'rule of thumb' adopted by ONS social surveys for publication[14].
Eurostat require five tables at the lowest geographical level (ward), Here it was assumed this is equivalent to MSOA. The most detailed person level table required at the MSOA level is age by sex (21 x 2). Assuming that the national age/sex distribution, (taken from the 2011 Census), holds at MSOA level then prevalences[15] across the age/sex groups range from 0.20 % to 3.69 % with a median of 2.97 %. If the socio-demographic survey allowed estimation of cells with a prevalence of 3% with a 20 % CV at the MSOA level then it was assumed that Eurostat requirements had been met. Although there will be some cells with smaller prevalences both in this table and other tables (50 % for this table), since no accuracy targets were stipulated by Eurostat then this was taken as a guide. Work undertaken by Beyond 2011 (see Beyond 2011, Producing Socio-demographic Statistics 2, Paper M12*)* showed that an achieved sample of 5.8 million people was required to estimate cells with a prevalence of 3 % with a 20 % CV at the MSOA level.

[13] For a guide to the different types of geography see http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/index.html
[14] For a discussion of reliability thresholds in the context of the Labour Force Survey see (ONS, 2011) pp51-52
[15] The prevalence is the percentage of the population to which the characteristic applies. For example, if 20 people were male aged between 70 and 74 in a population of 1,000 then the prevalence would be 20/1000 or 2 %.

Box 3: Terminology used in expressing population characteristic quality levels

CV – Coefficient of variation

The CV is a statistical measure of the variability associated with an estimate relative to the size of the estimate itself. It is expressed as a percentage, and in general the lower the percentage the better the quality of the estimate.

In the case of a characteristics survey typically the smaller the sub-population being estimated (i.e. the lower the percentage in the sample population), the larger the CV as there are fewer observations (or survey interviews) on which to base the estimate.

The table below shows the CVs associated with estimates of different sizes within an average sized LA level from the three different survey designs consideration in the second options assessment by the Beyond 2011 Programme[16]. It highlights that the smaller the sub-population being estimated, the larger the associated CV.

Size of sub-population	CV from 10% 10-yearly survey	CV from 4% annual survey	CV from 40% 10-yearly survey
1,000	7.9%	12.6%	5.6%
10,000	3.1%	5.0%	2.2%
50,000	1.2%	1.9%	0.9%

The relationship between the CV and the 95 % confidence interval (see Box 1) is such that the relative 95% confidence interval is 1.96 times the CV.

For example, from the table above an estimate of 10,000 from a 4% annual survey has a CV of 5.0%. The confidence interval can be calculated as follows:

Lower limit = 10,000 – (1.96 x 5.0% of 10,000) = 10,000 – (1.96 x 500) = 9,020

Upper limit = 10,000 + (1.96 x 5.0% of 10,000) = 10,000 + (1.96 x 500) = 10,980

This gives a confidence interval of 9,020 to 10,980

Rolling average – An estimate based on combining survey data over a number of years, eg for the last three or five years. For example, if a three year rolling average was used, the estimate for 2010 would refer to data collected over the period 2009 to 2011, and would be published in 2012/13. The next estimate, for 2011, published in 2013 would be based on data collected over the period 2010 to 2012.

OA[17] – Output Area – Total population between 100 and 625 people, average 300 people

LSOA[5] – Lower Layer Super Output Area – Total population between 1,000 and 3,000 people, average 1,600 people

MSOA[5] – Middle Layer Super Output Area – Total population between 5,000 and 15,000 people, average 7,800 people

LA[5] – local authority – Total population between 2,200 and 1,074,000, average 160,000 people

[16] For further information see Beyond 2011 Options Report 2
[17] For an introduction to the different types of geography see http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/index.html

Within the Eurostat requirements the most detailed person level table at the LA level is age by sex by household status (21 x 2 x 11). Assuming the national level household status (taken from the 2001 Census with some adjustment) and the national age/sex distribution holds at the LA level then prevalences in this table will range from 0.002 % to 1.87 % with a median of 0.2 %. Therefore it was assumed here that in order to meet Eurostat requirements the socio-demographic survey must allow estimation of cells with a prevalence of 0.2 % with a 20 % CV at the LA level. Beyond 2011 'Beyond 2011: Options Report' Options Report O1 showed that an achieved sample of 4.4 million people would be required to meet this standard.

The quality standards above for MSOA and LA can be linked to A1. In order to meet Eurostat requirements (as a minimum) sufficiently accurate estimates would be regarded as LA statistics for a population with 0.2 % prevalence have a CV of 20 % or less and MSOA level statistics for a population with 3 % prevalence have a CV of 20 % or less. These would need to be produced every 10 years.

Note, these standards were based on the most detailed Eurostat requirements, further work could be undertaken to consider how detailed the majority of census tables are in comparison to these Eurostat tables. An initial review of 2011 Census Key Statistics tables showed that prevalences would be greater than for the Eurostat tables, ie. each table had a smaller number of cells.

The A2 design standard builds on A1 and considered producing estimates with a similar level of accuracy to A1, but more frequently, hence exceeding the Eurostat requirements. The proposal was made to meet Eurostat requirements at the LA level would require a sample of approximately 2.2 million people each year. Given A1 this would also mean that the MSOA Eurostat requirements would be met by rolling together three years worth of data. The proposal was that annual LSOA estimates would be based on a rolling average of five years worth of data, with a 20% CV achieved for a prevalence of 8% at LSOA level. Local authority estimates would therefore be based on one or three years of survey data depending on the prevalence and whether quality standards are met.

The design standard for A3 builds on A1. Rather than producing estimates more frequently estimates would be produced at a lower level of geography to the required 20 % CV. A3 involves producing estimates every 10 years exceeding the quantitative standards for A1 but also including the following standard for estimates at OA level, for OA level statistics the standard for 20% CV was proposed for a prevalence of 10%. In order to meet this standard a sample of approximately 37.5 million people would be required.

Illustrative examples of different prevalences and CVs and what they would mean in reality for estimates in England and also in Wales are provided in Table A3 below.

Table A3: Quantitative Design Standards for Population characteristics - Illustrative examples

Quantitative design standards	Illustrative Examples (approx)
LA statistics for a population with 0.2% prevalence have a CV of 20% or less	Assume average LA population size in England is 160,000 0.2% prevalence would mean cell size of 320 CV of 20% would result in a 95% CI of [192,448] Assume average LA population size in Wales is 140,000 0.2% prevalence would mean cell size of 280 CV of 20% would result in a 95% CI of [168,392]
MSOA statistics for a population with 3% prevalence have a CV of 20% or less	Assume average MSOA population size in England is 7800 3% prevalence would mean cell size of 234 CV of 20% would result in a 95% CI of [140,328] Assume average MSOA population size in England is 7500 3% prevalence would mean cell size of 225 CV of 20% would result in a 95% CI of [135,315]
LSOA statistics for a population with 8% prevalence have a CV of 20% or less	Assume average LSOA population size in England is 1600 8% prevalence would mean cell size of 128 CV of 20% would result in a 95% CI of [77,179] Assume average LSOA population size in Wales is 1600 8% prevalence would mean cell size of 128 CV of 20% would result in a 95% CI of [77,179]
OA statistics for a population with 30% prevalence have a CV of 20% or less	Assume average OA population size in England is 300 30% prevalence would mean cell size of 90 CV of 20% would result in a 95% CI of [54,126] Assume average OA population size in Wales is 309 30% prevalence would mean cell size of 93 CV of 20% would result in a 95% CI of [56,130]
OA statistics for a population with 10% prevalence have a CV of 20% or less	Assume average OA population size in England is 300 10% prevalence would mean cell size of 30 CV of 20% would result in a 95% CI of [18,42] Assume average OA population size in Wales is 309 10% prevalence would mean cell size of 31 CV of 20% would result in a 95% CI of [19,43]

A4 Summary of quality standards

In order to assess the statistical quality (essentially accuracy, frequency and geography) of estimates produced by different options under consideration in the Beyond 2011 Programme theoretical quality standards were set. This appendix has set out how the quantitative quality standards used in the options assessment process were established. The standards for population estimates were based on the maximum, average and minimum quality of population estimates produced using our current system. Standards for population characteristics (derived from a socio-demographic survey) were derived by assuming that minimum requirements are to meet Eurostat regulations. These standards should be seen as indicators of the levels of acceptable quality.

The following quality standards were proposed for population estimates:

Population estimates (produced annually at the local authority (LA) level)	**Quantitative design standards**
P1 Maximum quality in the current system (ie. what is achieved in a census year)	97% of LA population estimates have a 95% confidence interval of ±3% or better
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year 97% of LA population estimates have a 95% confidence interval of ±3% or better In year nine, 97% of LA population estimates have a 95% confidence interval of ±6.0% or better
P3 Current average quality	97% of LA population estimates have a 95% confidence interval of ±5.2% or better

If required, standards are also set for ‘all local authority’ population estimates. The proposal made here are that these are 'softer' standards and the quality standards above are the primary set.

Population estimates (produced annually at the local authority (LA) level)	**Quantitative design standards**
P1 Maximum quality in the current system (ie. what is achieved in a census year)	All LA population estimates have a 95% confidence interval of ±3.8% or better
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year all LA population estimates have a 95% confidence interval of ±3.8% or better In year nine all LA population estimates have a 95% confidence interval of ±13% or better (excluding outliers)
P3 Current average quality	All LA population estimates have a 95% confidence interval of ±8.5% or better (excluding outliers)

Population estimates by quinary age and sex group (produced annually at the local authority (LA) level)	Quantitative design standards
P1 Maximum quality in the current system (ie. what is achieved in a census year)	97% of LA population estimates have a 95% confidence interval of ±7.2% or better
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year 97% of LA population estimates have a 95% confidence interval of ±7.2% or better In year nine, 97% of LA population estimates have a 95% confidence interval of ±14.4% or better
P3 Current average quality	97% of LA population estimates have a 95% confidence interval of ±12.5% or better

National quality standards are as follows:

National population estimate - England and Wales (produced annually)	Quantitative design standards
P1 Maximum quality in the current system (ie. what is achieved in a census year)	The national population estimate has a 95% confidence interval ±0.15%
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year the national population estimate has a 95% confidence interval ±0.15% In year nine the national population estimate has a 95% confidence interval ±0.27%
P3 Current average quality	The national population estimate has a 95% confidence interval ±0.22%

National population estimates by quinary age and sex group - England and Wales (produced annually)	Quantitative design standards
P1 Maximum quality in the current system (ie. what is achieved in a census year)	97% of national estimates by quinary age and sex group have a 95% confidence interval of ±0.6% or better
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year 97% of national estimates by quinary age and sex group have a 95% confidence interval of ±0.6% or better In year nine 97% of national estimates by quinary age and sex group have a 95% confidence interval of ±1.0% or better
P3 Current average quality	97% of national estimates by quinary age and sex group have a 95% confidence interval of ±0.8% or better

National population estimate - England (produced annually)	Quantitative design standards
P1 Maximum quality in the current system (ie. what is achieved in a census year)	The national population estimate has a 95% confidence interval ±0.15%
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year the national population estimate has a 95% confidence interval ±0.15% In year nine the national population estimate has a 95% confidence interval ±0.28%
P3 Current average quality	The national population estimate has a 95% confidence interval ±0.23%

National population estimates by quinary age and sex group - England (produced annually)	Quantitative design standards
P1 Maximum quality in the current system (ie. what is achieved in a census year)	97% of national estimates by quinary age and sex group have a 95% confidence interval of ±0.6% or better
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year 97% of national estimates by quinary age and sex group have a 95% confidence interval of ±0.6% or better In year nine 97% of national estimates by quinary age and sex group have a 95% confidence interval of ±1.1% or better
P3 Current average quality	97% of national estimates by quinary age and sex group have a 95% confidence interval of ±0.9% or better

National Population Estimate - Wales (produced annually)	Quantitative design standards
P1 Maximum quality in the current system (ie. what is achieved in a census year)	The national population estimate has a 95% confidence interval ±0.64%
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year the national population estimate has a 95% confidence interval ±0.64% In year nine the national population estimate has a 95% confidence interval ±1.06%
P3 Current average quality	The national population estimate has a 95% confidence interval ±0.81%

National population estimates by quinary age and sex group - Wales (produced annually)	Quantitative design standards
P1 Maximum quality in the current system (ie. what is achieved in a census year)	97% of national estimates by quinary age and sex group have a 95% confidence interval of ±2.7% or better
P2 Current peak and trough (ie. peak level in the current system, declining over 10 years)	In the peak year 97% of national estimates by quinary age and sex group have a 95% confidence interval of ±2.7% or better In year nine 97% of national estimates by quinary age and sex group have a 95% confidence interval of ±4.5% or better
P3 Current average quality	97% of national estimates by quinary age and sex group have a 95% confidence interval of ±3.4% or better

In addition the standard is to produce unbiased estimates. As an indicator a bias of 0.5% or greater at the national level would be unacceptable for total population and a bias of 1.3% would be unacceptable for age sex groups. At the more local level a bias of 0.4% or greater would not be acceptable both for total population and within age sex groups.

In order to evaluate the options, each option needed to be assessed against the standards. For administrative options this required a combination of empirical testing and simulation (under reasonable model assumptions).

The following quality standards were proposed for population characteristics:

Population characteristics	Quantitative design standards
A1 LA and MSOA data every 10 years	LA statistics for a population with 0.2% prevalence have a CV of 20% or less MSOA statistics for a population with 3% prevalence have a CV of 20% or less
A2 LA, MSOA and LSOA data annually based on rolling 1 to 5 years of survey data	Exceeding the accuracy standards for A1 plus: LSOA statistics for a population with 10% prevalence have a CV of 20% or less
A3 LA, MSOA, LSOA and OA data every 10 years	Exceeding the standards for A1 plus: OA statistics for a population with 10% prevalence have a CV of 20% or less

These quality standards were defined for use in the research phase of the Beyond 2011 Programme. It was recognised that these standards should not be used in isolation when evaluating the quality of population estimates, but should be considered alongside other diagnostic tests such as comparing estimates to external sources, undertaking demographic analysis, comparing estimates over time and quality issues associated with the challenges of using administrative data. Further research would also be required to understand the implications for estimates for households and estimates of change over time.

Appendix references

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