

8 Data quality

Introduction

8.1 The quality of a census is about producing results that are fit for purpose and meet user requirements, ensuring that accurate and relevant results are produced to sufficient quality when they are required. Informing users about the quality of the data, and hence its limitations, is also crucial to aiding users' interpretation and understanding of the results. This chapter summarises the results of ONS's assessment of the accuracy of the 2011 Census.

8.2 The key measures of accuracy in a census are as follows:

Sampling error

- Where estimates of the population were based on a sample, they were subject to sampling error. ONS used confidence intervals to measure the sampling variability.

Non-sampling error

- *Coverage error*: is expressed as a response rate derived using information from the Census Coverage Survey (CCS) and the subsequent process of coverage assessment and adjustment to measure and adjust for under- and over-count (see paragraphs 5.60 to 5.64)
- *Non-response error*: occurred when respondents failed to answer all the questions or made errors in their responses, and is measured from the results of the edit and imputation process (see paragraphs 5.38 to 5.51). ONS used item non-response and item-imputation rates for the main census questions to assess item non-response error. This chapter focuses on item non-response
- *Measurement error*: occurred when respondents failed to provide correct information. ONS used results from a census quality survey (CQS) to measure the accuracy of respondents' answers to the census questions

8.3 This section focuses on sampling errors and the main sources of non-sampling errors. Not all of the non-sampling errors relevant in a census are covered here. For example, non-sampling errors arising from error in online response and coding; frame errors from the address register; and timing or recall errors (where not everyone is responding about the same day) are not discussed either because they are not major sources of error or because they cannot be measured.

8.4 More information about other standard dimensions of quality used by ONS (such as relevance, timeliness and punctuality, comparability, coherence, output quality tradeoffs, and assessment of user needs) are covered in more detail in an ONS *Census Quality and Methods* paper on the ONS website⁶¹. Some of these aspects are also covered indirectly in other chapters of the General Report. For example, relevance relates to how well the information relates to user needs; the section on questionnaire design (see paragraphs 2.72 to 2.94) outlines the extensive and thorough user consultation done by the programme to ensure that the information collected met user needs.

Accuracy of the census population estimates

Sampling error: confidence intervals around the census estimates

- 8.5 The 2011 Census built on the methods and processes used in 2001 to measure and adjust both for under-coverage (those people and households missed from the census count) and over-coverage (those people and households counted more than once). This measurement and adjustment process was called coverage assessment and adjustment (CAA) – see paragraphs 5.60 to 5.64.
- 8.6 The main success criteria for the CAA process centred on the degree of precision it could achieve in estimating the population from those who responded to the census when compared with a sample of respondents to the independent CCS– see chapter 4. Because the census estimates produced using the CAA process were based on the CCS sample, they were subject to sampling error. As with any sample, different people would be selected if the sample was randomly drawn again, and slightly different estimates would be produced based on this different sample. The spread of these estimates is known as the sampling variability, and confidence intervals are used to present the sampling variability. A 95 per cent confidence interval is a range within which the true population parameter would fall for 95 per cent of all possible samples that could have been selected. If an estimate has a large error level, the corresponding confidence interval will be very wide.

Table 8.1 Confidence intervals (95 per cent) for 2001 and 2011 Censuses, England and Wales

Census	Population estimate	95 per cent confidence interval (+/-)	Lower confidence interval	Upper confidence interval
2001	52,042,000	0.21%	51,932,700	52,151,300
2011	56,075,900	0.15%	55,992,900	56,158,900

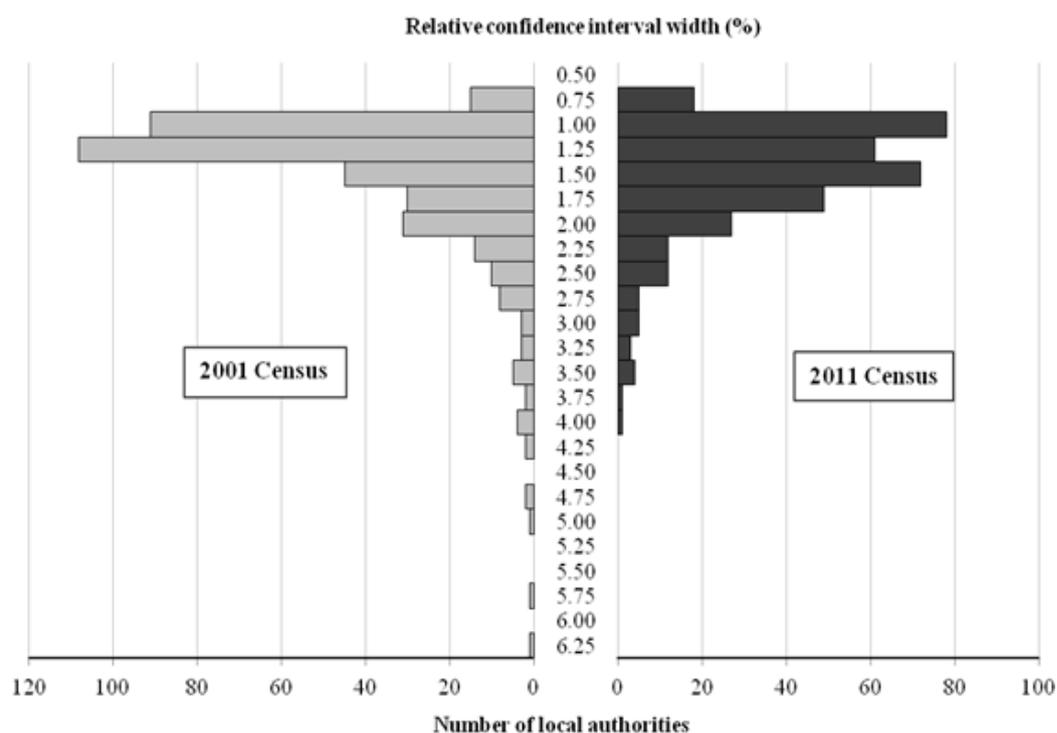
- 8.7 Table 8.1 shows the 95 per cent confidence interval achieved on the population estimate for England and Wales for the 2011 and 2001 Censuses. It shows that the 95 per cent confidence interval achieved on the population estimate was +/- 0.15 per cent (83,000 people). That is, the true population count is expected to be within 83,000 of the published population estimate. This is an improvement over 2001 when the confidence interval was wider at +/- 0.21 per cent (109,300 people).

Confidence intervals around the local authority estimates

- 8.8 A key aim of the census was to produce robust, fit for purpose estimates at the local authority (LA) level, and this drove the design of the census. Robust estimates for LAs are important because this geography has the greatest use in policy planning and delivery of services, for example the allocation of resources from central to local government. This was interpreted to mean that the quality of the LA level estimates should be high, and the quality should not vary substantially across LAs (as they had done in 2001).
- 8.9 The sampling error associated with the 2011 Census estimates at the LA level depended on: the CCS sample size; the size of the population; the census response rate; the variability of the response rate within the LA; the CCS response rate; and the degree of similarity of the population that the error level related to.

8.10 As shown in figure 8.1, for the 2011 Census the range of relative 95 per cent confidence intervals for local authorities is considerably narrower than in 2001, ranging from an interval of +/- 0.6 per cent to +/- 3.8 per cent in 2011, compared with +/-0.6 per cent to +/- 6.1 per cent in 2001.

Figure 8.1 Distribution across local authorities of 95 per cent relative confidence interval width for the 2001 and 2011 Censuses



8.11 Table 8.2 summarises the proportion of LAs whose confidence interval fell within a particular range for both the 2011 and 2001 Censuses. In 2011 more than 97 per cent of LAs had a 95 per cent confidence interval of +/- 3 per cent or better, with the widest interval at +/- 3.8 per cent. That is, nine LAs (nearly 3 per cent of all LAs), had a 95 per cent confidence interval wider than 3 per cent compared with 21 LAs (5.6 per cent) in 2001.

Table 8.2 Percentage of LAs with their relative 95 per cent confidence intervals for the 2011 and 2001 Censuses, England and Wales

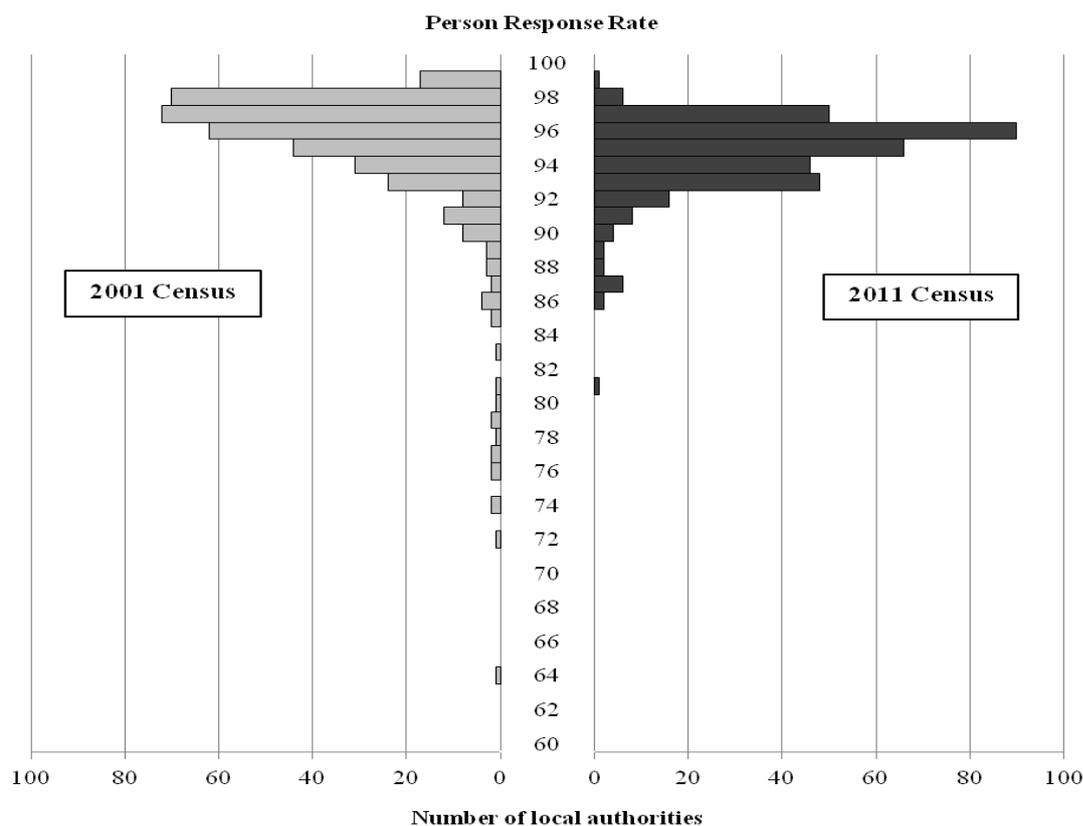
Census	Total LAs	Relative confidence interval						
		+/- 1%	+/- 2%	+/- 3%	+/- 4%	+/- 5%	+/- 6%	+/- 7%
2011	348	27.6	60.1	9.8	2.6	0.0	0.0	0.0
2001	376	28.2	56.9	9.3	3.7	1.3	0.3	0.3

8.12 Further reporting on confidence intervals for age, sex, ethnic group, activity last week and tenure, all by region or local authority, are available to download from the report *Confidence intervals for the 2011 Census*⁶².

Response rates

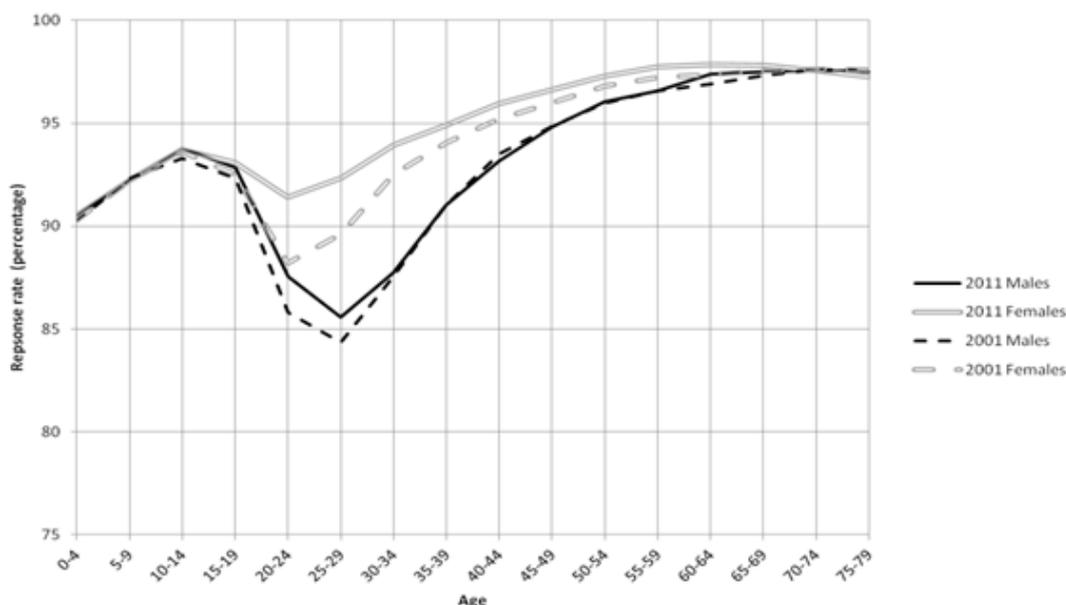
- 8.13 As well as depending on the CCS sample size, confidence intervals are also dependent on the response rate to the main census; in particular the variability in response rates between areas.
- 8.14 Achieving narrow confidence intervals was not enough to deliver the quality estimates that users required, especially for small areas and small populations. Maximising overall response rates and minimising variation in response rates across population groups were also critical to ensure that there were no particular gaps in the population estimates. Therefore, reviewing response rates and variation in response helps to understand further the coverage of the census estimates.
- 8.15 The overall response rate to the 2011 Census was 94 per cent. The 2011 CAA methodology was able to derive census population estimates that represented 100 per cent of the population, by using the CCS and other statistical techniques to estimate the numbers and characteristics of the people who were missed.
- 8.16 A response rate of 93.9 per cent indicates that an estimated 6 per cent of the total population of England and Wales did not respond to the census. In all, of the 56.1 million estimated people, about 3.8 million were thought to have been missed and subsequently adjusted for during data processing. This overall response rate of 93.9 per cent is slightly higher than the 93.7 per cent achieved in 2001. Note that after publishing census population estimates in 2001 there were further revisions to the estimate of non-responders which suggested a final post-census adjusted rate of 93.4 per cent.
- 8.17 As mentioned in paragraph 8.8, a key aim of the census was to produce robust, fit for purpose estimates at the LA level, and, in particular, to minimise the variation in response across local authorities.
- 8.18 Figure 8.2 shows the distribution of response rates by LA for the 2001 and 2011 censuses. It shows a significantly reduced variation across LAs between the two censuses. In 2001 some 13 local authorities had response rates below 80 per cent and 38 below 90 per cent, whereas in 2011 response rates were over 80 per cent in all LAs, and in only 13 were they below 90 per cent – indicating that the 2011 Census was successful in achieving its aim.

Figure 8.2 Distribution of person response rates across local authorities, 2001 and 2011 Censuses



8.19 Figure 8.3 compares age-sex response rates for the 2001 and 2011 Censuses. An aim for the 2011 Census was to ensure that the lowest response was as least as good as that achieved in 2001. In 2011, some 33 out of 36 age-sex groups (92 per cent) had response rates of 90 per cent or higher. All but one had a response rate of 87 or higher, with only males aged 25 to 29 with a lower rate (86 per cent). The figure shows that the 2011 Census was more successful at counting both young females and young males, especially those aged 20 to 29, to whom additional resources and priority was given during the enumeration. However, the differential response rate between males and females has widened in these groups.

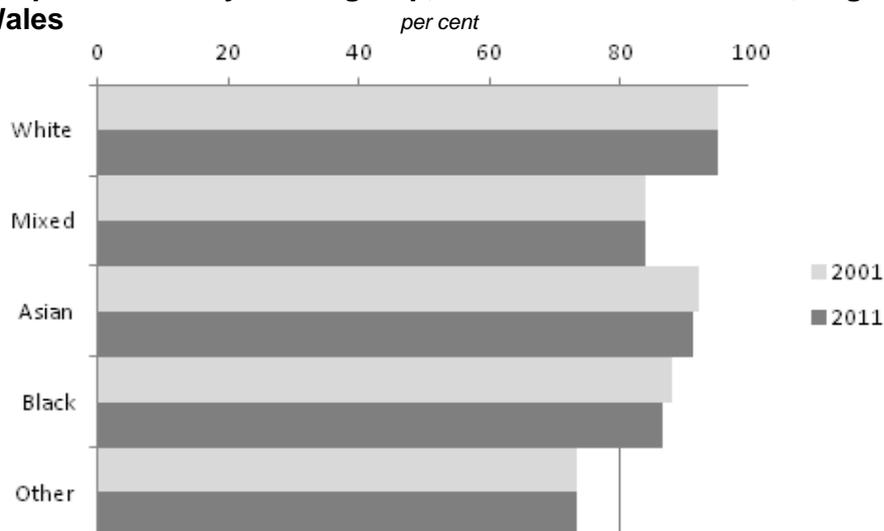
Figure 8.3 Response rates by five-year age group and sex group, 2001 and 2011 Censuses



Ethnicity

8.20 There was also an aim that response rates among ethnic groups should be better, or at least no less, than in 2001. Again the aim was to minimise the variation of levels of response among particular groups of the population. Figure 8.4 shows response rates for the main ethnic groups recorded in the 2001 and 2011 censuses. It shows that for each group there was very little difference between the 2001 and 2011 response rates, with the largest difference being in those who identified themselves as ‘Black’ (1.7 percentage points). However, it is worth noting that it is not possible to adjust the 2001 response rates by ethnic group to take account of the post-census adjustments. If this adjustment was possible, the 2001 response rates would be slightly lower, but would be unlikely to significantly alter the comparison.

Figure 8.4 Response rates by ethnic group, 2001 and 2011 Censuses, England and Wales



Non sampling error: accuracy of information collected

8.21 Another key objective for the quality of data was to provide the most accurate possible information about the structures and characteristics of the population of England and Wales. Meeting this objective mainly depended on a combination of high levels of completeness of the census questionnaires, and accurate responses to the individual questions on which information was collected. These two aims were assessed as follows:

- *levels of completeness* measured through item non-response rates (for example the rate of non-completion for a particular question, such as 'sex', on a returned questionnaire) as derived from the start of the edit and imputation process, and
- *measurement error* as measured through the CQS, in which a sample of respondents to the census were re-asked the census questions in a face-to-face interview, and their answers compared with their responses in the census to derive measures of agreement

Assessing the completeness of census responses: item non-response rates

8.22 A key user requirement for the 2011 Census was that the census database should be as complete and consistent as possible. To meet this need, as in 2001, an edit and imputation system was developed to estimate missing or invalid responses and correct inconsistencies in the data, while at the same time preserving the relationships between variables (see paragraphs 5.38 to 5.51).

8.23 Completeness is an indirect assessment of how well the self-completion census questionnaire was designed. High levels of completeness indicate that the methods and effort put into qualitative and quantitative testing of individual groups of questions and then the whole questionnaire were successful and had a positive impact on maximising completeness and the accuracy of responses. Other key factors which contributed to completeness were: the online help available for both those that completed their questionnaire online and for respondents who used the paper form; the availability of the contact centre to answer questions by phone; and the support and guidance of collectors on the doorstep. Completeness was assessed by measuring how many responses to each census question were missing as a proportion of all of the people who should have responded to that question (but not including persons and whole households that were missed).

8.24 Item non-response includes all responses that were missing or not valid, including multi-ticks, out-of-range values and partially answered responses. Item imputation was applied to estimate for a missing value when there was item non-response or where there were inconsistency errors. The latter were where correctly recorded values were considered invalid because they were inconsistent either with other values on the questionnaire, or with auxiliary information or definitions. Inconsistency errors were detected by validating the data against a set of pre-defined edit rules. For example, the rule which stated that a person aged less than 16 cannot have a qualification would have flagged a record where a person was recorded as being aged five but with a university degree.

8.25 Item non-response rates for the main census questions are shown in Table 8.3. Item non-response rates for the household questions ranged from 2.3 per cent for 'tenure of household' and 'number of cars and vans' to 3.6 per cent for 'type of central heating'. All household questions had item non-response rates lower than in 2001,

apart from the question on central heating where the rate increased from 2.2 per cent to 3.6 per cent.

- 8.26 For individual questions, the item non-response rate showed wider variation ranging from only 0.4 per cent for 'sex' to 14.5 per cent for the new question on 'intention to stay'. Other notably high item non-response rates were for the 'workplace postcode' (12.5 per cent) and 'year last worked' (10.9 per cent). Of the 43 variables shown, 35 (81 per cent) had an item non-response rate of 5 per cent or less.
- 8.27 The item non-response rates for the majority of questions were lower or very close to the 2001 rates apart from 'workplace postcode' (4.7 percentage points higher), 'marital status' (3 percentage points higher), and 'schoolchild/student indicator' (2 percentage points higher). However, it is worth noting that there are some differences in the way non-response rates were calculated between the two censuses. The overall message that there has been less non-response in 2011 than in 2001 does not change. But the 2001 results were measured after the application of some hard edits which means that for some questions they will underestimate the level of non-response. There were considerably fewer hard edits applied in 2011 than in 2001.

Table 8.3 Item non-response rates, 2001 and 2011 Censuses, England and Wales

Census questions	2001 Census			2011 Census		
	Total*	Non-response		Total*	Non-response	
	(000s)	(000s)	Rate (%)	(000s)	(000s)	Rate (%)
<i>Household questions</i>						
Type of accommodation	22,305	671	3.0	22,877	583	2.5
Self contained	22,305	870	3.9	22,877	638	2.8
Number of rooms	20,542	1,117	5.4	22,877	710	3.1
Number of bedrooms	-	-	-	22,877	600	2.6
Central heating	20,383	442	2.2	22,877	821	3.6
Tenure	20,383	685	3.4	22,191	508	2.3
Type of landlord	5,954	175	2.9	7,718	215	2.8
Number of cars or vans	20,383	554	2.7	22,191	501	2.3
<i>Individual questions</i>						
Age	49,359	262	0.5	53,483	319	0.6
Sex	49,359	199	0.4	53,483	225	0.4
Marital/civil partnership status	49,359	372	0.8	53,483	2,052	3.8
Second address indicator	-	-	-	53,483	1,486	3.5
Type of second address	-	-	-	3,274	219	6.8
Schoolchild/student	49,359	622	1.3	53,483	1,745	3.3
Term-time address indicator	-	-	-	11,607	159	1.4
Activity last week	-	-	-	43,041	2,172	5.1
Relationship to person 1	28,065	971	3.5	30,335	1,203	4.0
Country of birth	48,848	1,211	2.5	52,791	800	1.5
Arrival in the UK	-	-	-	6,858	326	4.8
Intention to stay	-	-	-	594	86	14.5
National identity	-	-	-	52,791	1,023	1.9
Ethnic group	48,848	1,405	2.9	52,791	1,595	3.0
Welsh language	2,754	151	5.5	2,861	96	3.4
Main language	-	-	-	52,791	1,328	2.5
Proficiency in English	-	-	-	3,929	142	3.6
Religion	48,848	3,721	7.6	53,068	3,759	7.1
Usual address one year ago	48,848	2,198	4.5	52,150	2,004	3.8
Passport held	-	-	-	56,754	1,315	2.3
General health	48,484	1,525	3.1	52,791	853	1.6
Provision of unpaid care	48,848	2,967	6.1	52,791	1,855	3.5
Long-term health/disability	48,848	1,899	3.9	54,791	1,675	3.2
Qualifications	35,367	2,187	6.2	43,041	2,433	5.7
Ever worked	-	-	-	17,787	316	1.8
Year last worked	-	-	-	14,433	1,569	10.9
Employment status	33,686	2,205	6.5	39,687	1,582	4.0
Occupation (working)	21,741	694	3.2	25,255	578	2.3
Supervisor status	33,686	2,294	6.8	39,687	1,711	4.3
Industry (working)	21,741	1,702	7.8	25,255	1,813	7.2
Workplace postcode	22,396	1,744	7.8	20,371	2,548	12.5
Method of travel to work	22,533	1,410	6.3	25,255	796	3.2
Hours worked	22,533	1,804	8.0	25,255	854	3.4

* The total columns refer to the number of household or people in scope for each particular question

Assessing measurement error: Census Quality Survey (CQS)

- 8.28 Measurement errors in individual data can occur during the data collection stage of a census. Measurement error can be introduced by poorly designed questionnaires, field staff errors or respondent error.
- 8.29 The 2011 Census questionnaire was carefully designed and tested to reduce the likelihood of measurement error. Testing had determined the appropriate content and design for the questionnaire based on consultations with experts into design and format, as well as the assessment of public acceptability. Features aimed at reducing measurement error included:
- clarity of questions and the provision of clear instructions on the questionnaire
 - the exclusion of sensitive questions, such as income
 - careful ordering of the questions to avoid any context effects (which can occur when respondents answer an identical question differently depending on where on the questionnaire it was asked)
 - keeping the average time taken to fill in the questionnaire to a minimum to reduce burden
 - a written assurance of the strict confidentiality of any information collected
- 8.30 The CQS was a voluntary survey carried out across England and Wales after the 2011 Census. It aimed to measure the accuracy of answers given to census questions by asking a sample of households the census questions again in a face-to-face interview. By comparing the responses given in the CQS to those given in the census, agreement rates were calculated which provided an indication of how accurately the 2011 Census questionnaire had been completed by the general public. Along with other quality information published about the 2011 Census, the CQS results are intended to help users understand the strengths and limitations of the 2011 Census data and how to use them appropriately. Table 8.4 shows the agreement rates for individual and household questions.

Table 8.4 Agreement rates between 2011 Census and Census Quality Survey, individual and household questions

Census questions	2011 CQS agreement rates (per cent)	2011 CQS confidence interval width (+/- percentage points)
<i>Household questions</i>		
Type of accommodation	91.6	0.8
Self-contained	98.6	0.3
Number of rooms	66.5	1.3
Number of bedrooms	91.4	0.8
Central heating	90.2	0.8
Tenure	95.0	0.6
Type of landlord	87.6	1.8
<i>Individual questions</i>		
Age	98.4	0.3
Sex	99.7	0.1
Marital/civil partnership status	98.1	0.3
Second address indicator	97.1	0.4
Schoolchild/student	97.6	0.3
Term-time address indicator	98.9	0.5
Activity last week	91.2	0.6
Country of birth	99.1	0.3
National identity	60.4	1.4
Ethnic group	94.7	0.8
Main language	96.3	0.7
Religion	90.4	0.9
Usual address one year ago	95.5	0.6
Passports held	91.8	0.7
General health	68.2	1.2
Provision of unpaid care	90.9	0.7
Long-term health/disability	88.9	0.7
Qualification	67.6	1.0
Ever worked	94.4	0.7
Year last worked	55.0	1.5
Employment status	94.7	0.5
Occupation (highest)	67.5	1.0
Supervisor status	86.2	0.7
Industry (section code)	74.2	0.9
Workplace postcode	82.2	1.1
Method of travel to work	85.5	0.9
Hours worked	83.9	0.9

8.31 The CQS found that agreement rates ranged from 99.7 per cent for the question on 'sex' to 55.0 per cent for the question on 'year last worked'. The extent of agreement varied depending on the type of question: whether it was objective or subjective; whether it was answered by tick box or free text; and how many response categories it had.

8.32 More detailed analyses of the CQS are available from the report *2011 Census Quality Survey* which is downloadable from the ONS website⁶³.

Conclusion

- 8.33 Various indicators of data quality have been presented in this chapter that were used to guide the 2011 Census programme in its design and decision making. The overall aim of these indicators was to do at least as well as similar measures in 2001. In summary:
- 95 per cent confidence interval achieved on the population estimate was +/- 0.15 per cent (83,000 people), much narrower than the confidence interval in 2001 of +/- 0.21 per cent (+/-109,300 people) indicating more accurate population estimates (see paragraph 8.7)
 - In 2011, 97 per cent of local authorities had a 95 per cent confidence interval of +/- 3 per cent or better, compared with 94 per cent of local authorities in 2001 (paragraph 8.11)
 - The overall response rate for England and Wales in 2011 was 93.9 per cent, slightly better than the 2001 overall response rate of 93.7 per cent (paragraph 8.16)
 - All local authorities had a response rate above 80 per cent and only 13 had a response rate below 90 per cent, compared with 2001 where 13 local authorities were below 80 per cent and 38 were below 90 per cent (paragraph 8.18)
- 8.34 Based on these indicators the overall aim to maintain or improve data quality compared with 2001 has been very successful. Bearing in mind the trend of declining response to, and participation in, social surveys and previous censuses over the last three decades, these were challenging targets which the census has met.