CENSUS 2011: INDEPENDENT REVIEW OF COVERAGE ASSESSMENT, ADJUSTMENT AND QUALITY ASSURANCE

IAN PLEWIS[1], LUDI SIMPSON[2] and PAUL WILLIAMSON[3]

[1] Ian Plewis is Professor of Social Statistics, University of Manchester.

[2] Ludi Simpson is Honorary Professor of Population Studies, University of Manchester.

[3] Paul Williamson is Senior Lecturer in Population Geography, University of Liverpool.

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About the authors

Ian Plewis joined the University of Manchester in 2007 having previously worked in the Centre for Longitudinal Studies, Institute of Education, London. He recently directed an ESRC-funded project on Predicting and Preventing Non-response in Cohort Studies and has published extensively on the analysis of longitudinal survey data.

Ludi Simpson wrote the Local Government Association report, *The 2001 One Number Census and its quality assurance, a review,* and has written widely about Census fieldwork, response rates and population estimates. He worked in local government in Yorkshire from 1981 until 2003 before moving to the University of Manchester.

Paul Williamson was co-editor of *The Census Data System* – a user guide to the 2001 Census. He has published widely on population estimation and the analysis of census and survey data, and is an associate editor of the Journal of the Royal Statistical Society (Series A). He has been employed at the University of Liverpool since 1994.

Acknowledgements

Abbreviations used in the report

CANCEIS: Canadian Census Edit and Imputation System

CCS: Census Coverage Survey

CE: Communal Establishment (small up to 99 beds; large 100+ beds)

DSE: Dual System Estimation

EA: Estimation Area

ED: Enumeration District

GOR: Government Office Region

HMO: Houses in Multiple Occupation

HtC: Hard to Count

IHS: Integrated Household Survey

LA: Local Authority

LS: ONS Longitudinal Study

LSOA: Lower Super Output Area

OA: Output Area

ONS: Office for National Statistics

PAF: Postal Address File

QA: Quality Assurance

ToR: Terms of Reference

UKSA: United Kingdom Statistics Authority

Three different population counts

Census count: the population enumerated in the Census.

Census-CCS estimate: the population including an initial estimate of those missed using the Census Coverage Survey.

Final Census population estimate: the population including a final estimate of those missed, following QA.

Executive Summary

We have reviewed the plans of the Office for National Statistics (ONS) for Census coverage assessment, adjustment and quality assurance for the 2011 Census in England and Wales, as set out in the Terms of Reference (ToR).

We have addressed concerns expressed by Local Authorities (LA) in this report, as far as these concerns fell within our ToR. Conducting a convincing Census is a major undertaking, one that is fraught with difficulties and hazards, notably but not exclusively in London. We believe that the construction of a central address register will go a long way towards meeting LA concerns about households that are missed by all forms of enumeration but we recognise that some will remain unenumerated. We encourage LAs to supply ONS and Census area managers with all the intelligence they can about 'hard to enumerate' households.

We would like to put on record our belief that many lessons have been learned from the Census in 2001 (which was itself a considerable improvement over the 1991 Census). We have been impressed by the scope and depth of the methodological investigations initiated by ONS, by their willingness to discuss with a wide range of interest groups concerns about coverage and Quality Assurance (QA), and by the procedures that are in place to use field staff flexibly. We are reasonably optimistic that, having taken account of our recommendations to develop, document and consult on specific aspects of methodology, the 2011 Census in England and Wales will provide population <u>estimates</u> that can guide resource allocation and social policy in the right direction for the next ten years. It must, however, be recognised that the target 95% confidence intervals set by ONS for the population counts – a maximum interval of ± 3% for all LAs – are entirely contingent on achieving local as well as national targets for non-response.

Our recommendations for action by ONS are set out in the sections of this report and brought together here:

Recommendation 4.1: Provide a more timely breakdown than was achieved in 2001, at the same level of detail as in 2001, of response rates for the CCS. This will enable users to assess the robustness of the DSE adjustment.

Recommendation 4.2: Consider capturing data about household non-contact and refusal rates by CCS interviewer and analysing the data to provide additional intelligence for use in QA and ratio estimation.

Recommendation 5.1: Set out in detail, ideally with some examples, the way in which DSE is applied to data from the Census and the CCS to produce estimates both for each age-sex group and also for each ethnic group, making it clear when the assumption of independence between the Census and CCS has been relaxed, explaining which levels of aggregation have been used and how different forms of post-stratification (for example, tenure and ethnic group) have been used to strengthen the results. The methods used for small CEs should be included.

Recommendation 5.2: Publish a detailed assessment of Census-CCS matching success rates for automatic and manual matching (and for each EA).

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Recommendation 5.4: Given their use in subsequent outputs, give serious consideration to extending the quinary age groups to 90+, if necessary collapsing geography rather than age groups to secure sufficiently robust Census-CCS estimates amongst these higher age groups.

Recommendation 6.1: Clarify precisely how ONS will integrate the separate overcount propensities identified from its Census self-match and Census-CCS matching exercises as inputs to the DSE process.

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Recommendation 6.3: Publish estimates of the components of overcount associated with each EA and, where possible, LA, including both removal of duplicate returns from within same postcode and the net overcount adjustment arising from Census-CCS matching.

Recommendation 8.1: Clarify the circumstances in which an LA fixed effect will be favoured, including the presence of atypical features within the EA such as substantial HE student residents.

Recommendation 8.2: Publish the asymmetric confidence intervals derived from variance estimation in preference to symmetric confidence intervals, as those expert enough to use confidence intervals are likely to be expert enough to make use of this useful additional information.

Recommendation 9.1: Finalise and publish details of the planned large CE imputation process in sufficient time to receive user feedback before it is implemented and describe in the final documentation how imputation deals with small CEs.

Recommendation 9.2: Identify areas and population sub-groups with significant overcount and assess the extent of any bias that might be introduced by retention of duplicates, through a comparison of identified duplicate and missed records.

Recommendation 9.3: As in 2001, publish imputation rates for each LA, age, sex, ethnicity and intention to stay category, so that expert users can take account of these when undertaking their own analyses of Census data.

(a) Documentation and consultation prior to QA

Recommendation 10.1: In the light of our comments, identify those QA checks that are so strong that they are able to be used to improve the Census where necessary.

Recommendation 10.2: Provide a unified overview and detailed documentation of proposed QA methodology as soon as possible to allow users to understand its coherence.

Recommendation 10.3: Undertake discussion in Spring 2011 to gain users' confidence in the QA and in the post-QA improvement procedures.

Recommendation 10.4: Confirm that knowledgeable, impartial support would be sought from the LA concerned during QA, when encountering a difficult and unusual pattern of discrepancies between the Census population estimates and detailed QA checks.

(b) Preparation and implementation of QA

Recommendation 10.5: Use the strength of each QA check to prioritise QA work, giving low priority to work-intensive checks that are unlikely to be used in improving Census estimates. This priority should apply both in the current preparation for QA before summer 2011, and during the subsequent QA itself. In particular, the proposed procedures and datasets for post-QA improvement should each be fully specified and fully prepared prior to their use in QA. This does not preclude judgement and methodological refinements during the QA.

Recommendation 10.6: Prepare for and expect to undertake supplementary QA in LAs with the highest indications of concern from the HtC index and field reports.

Recommendation 10.7: Ensure that the timetable for coverage assessment and QA is sufficient for the likely requirements of in-depth investigation for a minority of LAs as well as the national investigation that can only be finalised when all LAs have been processed.

Recommendation 11.1: The QA indicators for ethnic group should not be considered for adjusting the Census.

Recommendation 11.2: The plans to target large households and HMOs in early collection should be as comprehensive as possible. Where ethnically diverse LAs with substantial numbers of recent immigrants have not provided lists of HMOs for targeting by early collectors, these lists should be sought with urgency, targeted in those LAs for which published numbers of HMOs are high.

1. Introduction

1.1 This report emanates from a request from the Office for National Statistics (ONS) via the Census Director (England and Wales) to the President of the Royal Statistical Society for a team to conduct an independent review of some aspects of the Census of Population in England and Wales in 2011. ONS' request was stimulated by concerns expressed by Local Authorities about potential coverage error in the 2011 Census, bearing in mind the problems of undercount experienced in some areas, notably in Manchester and Westminster, in 2001, as well as the perceived difficulties of conducting Censuses in the twenty first century.

1.2 Ian Plewis was initially approached by ONS to lead the review and he was joined by Ludi Simpson and Paul Williamson. They started work in October 2010 and this report reflects the work during the four month period up to the end of January 2011.

1.3 The Terms of Reference (ToR) for the review team are reproduced as Appendix 1. In brief, they were to consider the methods that ONS intend to use to produce estimates of the population in each Local Authority (LA) in England and Wales, broken down by (i) five year age-sex groups and (ii) ethnic group. It is important to note that important aspects of the Census, particularly those related to data collection such as questionnaire design and fieldwork methods, were not part of this review as final decisions on these aspects had already been taken by ONS in order to be properly prepared for the Census date of 27 March 2011. Consequently, we only comment on these issues in so far as they are connected to the issues of coverage assessment, adjustment and Quality Assurance (QA) that form the basis of this review.

1.4 The main task of the review team was to examine a range of documents supplied by ONS in order to reach informed judgments about the proposed methods. In addition, the review team had three all-day meetings with ONS staff, giving ONS staff the opportunity to expand on some issues and the review team to seek clarification about methods and procedures.

1.5 LAs fed their concerns to the review team via a request from ONS to organisations representing LAs to submit answers to a set of questions germane to the review. These questions, and the names of the responding organisations, can be found in Appendix 2. We refer to the concerns expressed by LAs throughout this report. We also consulted several senior academic Census users.

1.6 We stress that this report does not attempt to describe the arrangements for the 2011 Census in any more detail than is required for our review of the issues in our ToR, nor does it do any more than allude briefly to issues surrounding the conduct of any population Census. We do, however, provide references that interested readers can follow up for more detailed discussions.

2. The 2011 Census in England and Wales

2.1 Social change has made Census operations more difficult, and response rates have fallen just as they have for voluntary surveys. Some undercount is expected. The 2011 Census follows the same basic method as was used for the first time in 2001 (*ONS1*). It combines a full enumeration with an independently conducted Census Coverage Survey (CCS) that takes place after the Census and which will be used to adjust for undercount (see Sections 4-8). Thus the *Census counts* for the groups set out

in (1.3) are converted into *Census-CCS estimates* to include an allowance for those missed. These estimates are used to closely guide the imputation of extra records into the Census database in order to represent those estimated to have been missed (Section 9). QA compares this augmented Census database with external evidence and improves it where possible (Sections 10-11) The resulting final *Census population estimates* are expected to be less biased than if the estimation of coverage were not undertaken, because those missed by a Census tend to be different from those enumerated.

2.2   There are, however, many important differences between the 2001 and 2011 Censuses including:

(a)   A central address register has been developed to facilitate improved form delivery and field management.

(b)   Consequently, Census forms will be delivered to households by post in the great majority of cases.

(c)   Field staff have been initially allocated according to the likely response rate in each area of the country.

(d)   A questionnaire tracking system has been developed that will record, within 24 hours of collection, whether a questionnaire has been returned and thus whether an address has responded. This will provide management information for small geographic areas that will enable field staff activities to be further directed to areas where response rates are lowest.

(e)   There will be the facility to return the completed information online with consistency checks incorporated into the online system.

(f)   An 'intention to stay' question has been introduced in order to be able to derive estimates of short-term residents (staying for between three and 12 months) as well as 'usual residents' (staying at least 12 months).

(g)   The period of fieldwork for the Census has been extended so that the CCS will start six rather than three weeks after Census day.

(h)   Visitors are intended to be enumerated both at their usual address and at their address on Census day; in 2001 visitors were not specifically identified.

(i)   An estimate of overcount will be incorporated into the Census population estimates.

2.3   The aim of the Census managers is to achieve coverage of at least 94% of the population overall (as in 2001), at least 80% in every LA (a rate not achieved in 12 LAs in 2001, all in London) and an interval of less than 20 percentage points between the 2.5^{th} and 97.5^{th} centiles in the Output Area (OA) response rates within each LA by Hard to Count (HtC) stratum. In addition, the aim is to achieve a response rate of 90% overall in the CCS (the response rate was 91% in 2001). This might be difficult to achieve, bearing in mind the fall in response rates to wave one of the Labour Force Survey of about 10% over the last decade.

2.4   Raising the lowest response rates has been shown to be key to accurately estimating the number and location of those missed by the Census (*ONS2*). The Census field-force of 35K is half that of 2001. However, it will not be asked to deliver forms but will be almost entirely devoted to following up those households that have not returned a Census form.   We have not been asked to comment on the fieldwork plans, but we agree that the achievement of the targets for Census response will make the assessment of Census coverage considerably more accurate.

3.   Users' concerns

3.1   The concerns that have been expressed to us by major users of Census data, most comprehensively by the LA sector but also from within academic research, can be summarised as below, referring in parentheses to sections in this report where these concerns have been addressed. The final two sections of this report are also specifically designed to address users' concerns. We use the headings provided to LA representative organisations by ONS, though some concerns range wider than their heading indicates. These organisations all began their response with praise for the improvements that the Census offices have already undertaken in response to users' concerns.

Particular population groups at risk of under-estimation

(a)   The potentially poor response in very difficult areas characterised by houses in multiple occupation (HMO), residences above shops, flats and bedsits, irregular residency or legality, large households, specific recent immigrant groups not civically engaged; short-term migrants, caravan parks and marinas, traveller camps. (10.7, 10.11)

The most relevant datasets to adequately assess the plausibility of the Census population estimates

(b)   Inadequate use of local knowledge during QA, both to ensure accurate interpretation of evidence and to win confidence in the results. (10.13, 10.16, 10.17, 10.28, Rec. 10.4, Rec. 11.2)

(c)   The need for publication of measures of coverage, QA datasets and decisions for sub-national and small areas, to win understanding. (Rec. 4.1, Rec. 5.1, Rec. 5.2, Rec. 6.3, Rec. 9.3, 10.26)

(d)   The perceived inadequacy of most comparators to identify all but the most major Census inaccuracy. (Rec. 5.3, 10.5 – 10.11, 10.22, 10.24, Rec. 10.1, Rec. 10.5, 11.2, Rec. 11.1)

The most significant risks with the methodology

(e)   Will use of the address list for both fieldwork and QA lead to bias? (5.7)

(f)   Inadequate use of dummy forms and other fieldwork information. (Rec. 4.2, 9.9, 9.10)

(g)   Inadequate clarity about planned adjustments when the Census is shown to need adjustment. (Rec. 6.1, Rec. 8.1, Rec. 9.1, 10.19, 10.21, Rec. 10.5)

(h)   Inadequate documentation of the procedures for QA. (10.23, Rec. 10.2)

(i)   The unpredictable impact of new circumstances: in particular, use of the Internet, and post-out of questionnaires. (6.3, 6.4)

(j)   The ability to identify and deal with localised failure of Census fieldwork procedures, such as the lack of follow-up in a Census Co-ordinator's area. (10.7, 10.13)

(k)   An unrepresentative sample for the CCS leading to inaccuracy; the impact of student revision periods and holiday seasons on the CCS. (5.4 – 5.9)

(l)   Inadequate imputation of the differences between respondents and non-respondents. (9.3-9.5, Rec. 9.1, Rec. 9.2)

3.2   These concerns are naturally, in their majority, those that users expressed about the results from 2001. This review will probably allay the fears about some concerns by expressing the team's confidence in

specific improved procedures for 2011. The review also emphasises what can and should still be done to minimise the impact of other dangers expressed in these concerns.

4.   The Census Coverage Survey

4.1   The CCS has the following design. LAs form the primary stratum and Output Areas (OA) are the primary sampling units (psu). The OAs are stratified by a 5-category HtC index as described in *ONS3*. Approximately half the postcodes within an OA will be selected giving a total of about 17K postcodes and then all households enumerated within each postcode, giving a total of about 325K households. Details of the breakdown by LA can be found in *ONS4* .

4.2   There are differences from the CCS design used in 2001, notably the use of LAs rather than Estimation Areas (EA) as primary strata and the use of OAs rather than Enumeration Districts (ED) as psu's. ONS has addressed the disadvantages of the 2001 design (ONS 4) and we believe the 2011 design to be an improvement on that used in 2001. This, in turn, should strengthen the application of the Dual System Estimation (DSE) which is described and discussed in Section 5. See 8.1 and 8.2 for further discussion of the relation between EAs and LAs.

4.3   Detailed response rates for the 2001 CCS were published (*ONS5*) but not until November 2005. This leads us to our first recommendation:

Recommendation 4.1: Provide a more timely breakdown than was achieved in 2001, at the same level of detail as in 2001, of response rates for the CCS. This will enable users to assess the robustness of the DSE adjustment.

4.4   Household non-response in the CCS can take two forms: non-contact, i.e. interviewers failing to make contact with a household; and refusal, i.e. the household refusing to cooperate with the CCS interviewer. Sometimes, non-contact can be avoided if the interviewer uses intelligent strategies in terms of their call-back patterns. Also, information about non-contact and refusal rates by interviewer could be useful 'operational' intelligence when quality assuring the Census for an LA. Consequently we recommend:

Recommendation 4.2: Consider capturing data about household non-contact and refusal rates by CCS interviewer and analysing the data to provide additional intelligence for use in QA and ratio estimation.

5.   Dual System Estimation

5.1   DSE is a crucial element of the 2011 Census just as it was in 2001. We give only a brief description of the method here; a much more detailed explanation of the method and the assumptions on which it rests can be found in Brown et al. (2006).

5.2   The basis of DSE is that the responses to the Census and, in the sampled areas, the CCS, are independent. This independence includes using different data collection methods, different personnel and a different address frame. Following extensive matching procedures (*ONS6*) to ensure that individuals counted by either one or both data collections are correctly allocated, it is then possible to construct a 2 by 2 table (Table 1). This is done for each age-sex group within each OA in the CCS:

Table 1: Basic table for DSE

		CENSUS		
		Observed	Not observed	Total
CCS	**Observed**	n_{11}	n_{12}	$n_{1.}$
	Not observed	n_{21}	n_{22}	$n_{2.}$
	Total	$n_{.1}$	$n_{.2}$	$n_{..}$

5.3   The numbers in each of the cells are counts so, for example, n_{12} is the number of persons (or households) observed in the CCS but not in the Census. The n_{22} cell is unknown which means that $n_{.2}$, $n_{2.}$ and $n_{..}$ are also unknown. The 'odds ratio' $(n_{11}/n_{12})/(n_{21}/n_{22})$ would be 1 if the probabilities of responding to the Census and CCS were the same for all persons within a given age-sex group across the whole OA ('homogeneity') and were truly independent of each other. Then $n_{22} = n_{12}n_{21}/n_{11}$ and $n_{..}$ = $n_{22} + (n_{11} + n_{12} + n_{21})$.

5.4   The assumptions of homogeneity and independence are crucial here and they can break down for four reasons:

(a)   The probabilities of responding to either the Census or the CCS vary within an age-sex group in an OA.

(b)   Some people or households may have no chance of being included in either the Census or the CCS because their propensity to respond to government enquiries is zero.

(c)   There is a failure in the matching process. In particular, the wider gap in 2011 than in 2001 between the Census and CCS will lead to problems with households and individuals who move, and dwelling units that become vacant or unoccupied in the CCS sample areas, between the fixed Census date and the uncertain CCS date. This risk might be especially important in university and seaside towns with the onset of university exam revision times and early summer holidays. We understand that ONS plan to conduct CCS fieldwork in these areas first and this would go some way to addressing these issues.

(d)   Variability is introduced by the Canadian Census Edit and Imputation System (CANCEIS) process that imputes missing data on age and sex on the Census form before DSE (see 5.11), so that the counts in cells n_{11}, n_{12} and n_{21} (which are, in principle, known) are actually incorrect.

5.5   ONS' default position, with which we concur, is that the age-sex stratification will provide the best person estimate and the tenure stratification the best household estimate. Alternative estimates using strata based on ethnicity or other characteristics, could have a key role in QA (see 10.7).

5.6   It is only possible to get an estimate of coverage that does not make the assumptions listed in 5.4 if there is a good estimate of the odds ratio in Table 1, which will normally be more than 1. Then a bias adjustment can be made (*ONS7*, *ONS8*). This is possible for households completely missed by the Census, because it is expected that the address register generated for the Census will give a household count that is close to the true total when combined with information from the CCS interviewers (as described in *ONS9*). It will then be possible to estimate the true odds ratio for each HtC stratum within an EA. This allows adjustments to be made to the age-sex and ethnic group totals for every smaller area, on the basis of the degree of dependence (the odds ratio) observed for the EA.

5.7 We believe that the improvements made to the address register during the Census fieldwork, including checks on the accuracy of dummy forms filled in by Census Collectors, will provide a household count sufficiently good to be used in the way described by ONS. Its use in the proposed DSE bias adjustment will improve the Census-CCS estimates, by allowing for household dependence and heterogeneity, and thus the numbers of households missed by the Census and CCS in the aggregate for a whole EA and HtC stratum.

5.8 The household bias adjustment outlined is applied to estimates of persons, using the strong assumption that each household has size one. We have been reassured by modelling work undertaken by ONS indicating that the resulting estimates are reasonably robust to the assumption that adjustments for missing persons within households – which are expected to be smaller than adjustments for missing households - do not vary substantially by household size within strata (*ONS8*).

5.9 An additional bias adjustment is proposed for people missed within households that do return a form in the Census. It is proposed to match records from the Integrated Household Survey (IHS) with Census records in order to gain an independent estimate of numbers of people missed, that will be robust at least for each Government Office Region (GOR). We have not seen a sufficiently detailed description of this to be sure that it will be useful.

5.10 DSE will be applied to get estimates of the total population resident in the UK for three but less than 12 months and 12+ months, the distinction between the two groups relying on the 'intention to stay' question in the Census and CCS. Comments from the assessment arm of the UK Statistics Authority (UKSA) on the 'intention to stay' question (and hence on the population bases), and responses to these comments, can be found in (*ONS10*, *ONS11*). We do not have further comment, but estimates of the number of short-term immigrants in an LA are dependent on the success of the 'intention to stay' question.

5.11 Values for missing responses to specific Census questions are imputed when Census returns are first processed, using CANCEIS. The performance of CANCEIS is new for 2011 and lies outside the ToR of this review.

5.12 CEs with fewer than 100 bed spaces (small CEs) are included in the CCS (while larger CEs will be verified at the QA stage). The methods to be used for DSE adjustment are set out in *ONS12* and appear to us to be reasonable. Small CEs are, however, likely to experience high visitor turn-over, so there is a danger that the CCS will lead to upwardly biased adjustment if visitors are misclassified as residents in the Census but then moved on before the CCS. Set against this danger, the CE Census enumerators will be specially trained.

5.13 We are in broad agreement with the proposed DSE method but we do think it is important that the way the method is applied – and we recognise that this will, to some extent, depend on results from the field – is clearly described.

Recommendation 5.1: Set out in detail, ideally with some examples, the way in which DSE is applied to data from the Census and the CCS to produce estimates both for each age-sex group and also for each ethnic group, making it clear when the assumption of independence between the Census and CCS has been relaxed, explaining which levels of aggregation have been used and how different forms of post-

stratification (for example, tenure and ethnic group) have been used to strengthen the results. The methods used for small CEs should be included.

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Recommendation 5.4: Given their use in subsequent outputs, give serious consideration to extending the quinary age groups to 90+, if necessary collapsing geography rather than age groups to secure sufficiently robust Census-CCS estimates amongst these higher age groups.

6. Overcount

6.1 As well as missing people resident in a given area, a Census can overcount them. The potential for double-counting arises when the same person is recorded as resident on multiple Census returns submitted from the same or different addresses. Alternatively, a single Census return may be received, incorrectly recording a visiting or fictitious person as a resident, leading to an erroneous count.

6.2 Analysis of the 2001 Census suggests a double-counting rate of 0.4% (1 in 250). Two-thirds of these double counts were attributable to students enumerated as resident at both their home and term-time addresses. The erroneous count rate is unknown (*ONS13*).

6.3 ONS anticipates an increased level of overcount of between 0.5 and 1% in 2011 (*ONS13*), attributable to such factors as complex household living arrangements, the extended period of enumeration, use of both the internet and handwritten returns, mitigated to some extent by the data consistency checks built into online Census returns.

6.4 To address the issue of overcount, ONS has put in place the following arrangements for the 2011 Census (*ONS13,ONS14*)

(a) Additional Census instructions and questions designed to more fully enumerate and more accurately classify resident and visiting household members.

(b) Automated identification and removal of duplicate Census returns made from the same or a nearby address.

(c) Moving the timing of the ONS Longitudinal Study (LS) matching process, allowing an LS-based estimate of overcount to be fed back into Census processing as part of the QA process.

(d) The cross-matching of Census records that provide a second address with the Census records at that address to search for duplicates.

(e) A stratified sample of all Census records, cross-matched with all Census returns from the same GOR to estimate rates of double counting.

(f) Use of the CCS to estimate the EA-level propensity to be overcounted due either to duplicate returns as a resident from multiple addresses or to incorrect classification of a visitor as a resident.

(g) Combining the Census and CCS-based estimates of overcount with the initial DSE estimates of undercount to produce DSE estimates of net undercount.

6.5   A number of methodological points regarding the incorporation of estimated overcount propensities into the DSE have yet to be resolved. ONS plans theoretical confirmation of the role of the Chapman correction in the extension of the DSE estimator incorporating an adjustment for overcount (*ONS13*) and clarification of the strata used in adjustment.

6.6   ONS currently has no method for identifying or removing overcount attributable to fictitious returns, and we have been unable to identify any plausible solution overlooked by them. This gives rise to the theoretical, if low, risk that a significant level of fictitious returns within a specific area or population sub-group could lead to uncorrected bias in published Census estimates.

Recommendation 6.1: Clarify precisely how ONS will integrate the separate overcount propensities identified from its Census self-match and Census-CCS matching exercises as inputs to the DSE process.

Recommendation 6.2: If faced with timetable or resource pressures for estimating overcount, prioritise nationwide Census self-matching of those with a stated second address, or different address one year ago (not a currently listed ONS strata) above self-matching other strata less at risk of being a duplicate within the same GOR.

Recommendation 6.3: Publish estimates of the components of overcount associated with each EA and, where possible, LA, including both removal of duplicate returns from within same postcode and the net overcount adjustment arising from Census-CCS matching.

7.   Ratio Estimation

7.1   Following application of DSE in each sampled OA in the CCS, the ratio of the DSE estimate to the Census estimate will be calculated for the totality of sampled areas in the EA, HtC, age-sex group stratum. This ratio will never be less than one. The Census counts in all areas, whether in the CCS or not, will be multiplied by this ratio.

7.2   Ratio estimation is a standard statistical procedure and we are satisfied that it is the most appropriate strategy in this situation. There can, however, be risks when ratio estimation is applied if the ratio of the within stratum Census-CCS estimate to the Census count is particularly unusual in one or two OAs.

8.   Local Authority estimation

8.1   For the purposes of implementing DSE, the CCS is used to produce estimates for EAs. These EAs comprise one or more LAs and are designed to ensure that they include CCS coverage of at least 35 sample OAs (and hence a minimum sample in an EA of about 3.5K households). There are 37 LAs that form a single EA (*ONS14, ONS15*).

8.2   EAs will be constructed from spatially contiguous LAs as the benefits of combining socio-economically similar but spatially non-contiguous LAs has been found to be marginal, bearing in mind that stratification by age-sex and HtC is already in place (*ONS15*).

8.3   After extensive simulation modelling based on eight EAs (*ONS15, ONS16*) the default method chosen for splitting EA Census estimates into estimates for their constituent LAs is a synthetic estimator, in which the different Census response rates for the LAs of an EA are assumed to be entirely due to their composition in terms of age, sex and HtC areas.

8.4   However, where there is evidence of important variation in LA under-coverage rates within an EA, a local fixed-effects model will be used instead. In contrast, the fixed-effects model was used for all EAs in 2001. The fixed effects model allows for LA-specific differences in the relationship between the Census count and Census-CCS estimates, whilst 'borrowing strength' from the overall relationship observed at EA level. At present ONS have left undefined the precise trigger-point for switching from an EA-level synthetic estimator to a local fixed-effects estimator.

Recommendation 8.1: Clarify the circumstances in which an LA fixed effect will be favoured, including the presence of atypical features within the EA such as substantial HE student residents.

8.5   ONS are planning to publish not only point estimates of LA age-sex and EA ethnicity counts, but also a measure of their variability (95% confidence interval) that will reflect the uncertainty in the point estimate inherent in the adjustments to the original Census count using DSE, overcount, ratio and LA estimation adjustments. It will not, however, include any account of the uncertainty associated with item, person or household imputation (see Section 9). It is important for all users to recognise that the confidence intervals produced by ONS represent ONS' best estimate of the variability inherent in the final Census population estimates and that, moreover, the true counts can be expected to lie outside these limits 5% of the time.

Recommendation 8.2: Publish the asymmetric confidence intervals derived from variance estimation in preference to symmetric confidence intervals, as those expert enough to use confidence intervals are likely to be expert enough to make use of this useful additional information.

9.   Imputation of missing persons

9.1   The expectation is that the Census-CCS estimates described in previous sections will always exceed the Census count. To adjust the Census database for this undercount, additional households and persons will be added (imputed) to ensure that the final Census database matches the DSE. This imputation also covers missed residents in small and large CEs.

9.2   In 2001 5.7% of households and 6.2% of persons were imputed nationally (*ONS17*), with household and person imputation rates ranging from <1% in some rural LAs to >20% in 12 London boroughs. ONS estimate that approximately two thirds of persons missed in 2001 were members of wholly missing households.

9.3   At the heart of the imputation process (*ONS14, ONS18, ONS19*) are estimated propensities for types of household to be missed by the Census, and for types of resident missed within a counted household. These propensities will be derived from the Census-CCS matched sample (cell n_{12} in Table 1 – see (5.2)).

9.4   The propensities to be missed are used to select records from within a given EA (including late return forms) for use as a 'donor record'. These donor records provide the key characteristics of missing

persons and households being imputed, including age, sex, ethnicity and resident status (intention to stay).

9.5 The resulting records used to represent those missed are therefore drawn from the Census itself but resemble households and people in the CCS who were not counted in the Census. They make the Census database more like the true population on Census day. It is impossible to fully represent the characteristics of the much smaller number of households and people who were missed by both Census and CCS, even though their quantity has been estimated (cell n_{22} in Table 1 – see (5.2)), but they will at least be placed in the correct strata (age, sex, HtC group).

9.6 A modified version of the imputation system outlined above will be used to impute persons in large CEs, but ONS has yet to finalise the details of its implementation.

9.7 The proposed 2011 Census imputation procedure is an amended version of that undertaken in 2001. The main change of significance to LA estimates of age-sex groups and ethnicity distributions is reversal of imputation order, with missed persons in counted households being imputed before persons in wholly missed households. ONS believes this change should ensure that the imputed Census database far more closely fits the DSE, significantly reducing the amount of 'pruning and grafting' required in 2001 (Steele et al., 2002) to ensure the final imputed database simultaneously meets the required household and person level DSE estimates.

9.8 The imputation process leads to an adjusted census database that will closely, but not exactly, match the Census-CCS estimate of age, sex and ethnicity counts for each LA. Where these differences exceed acceptable tolerance levels ONS will, as in 2001, undertake a second round of imputation, involving the addition and removal of imputed persons and households ('grafting' and 'pruning') .

9.9 Other changes in Census operations are likely to lead to improved imputation. These include:

(a) Revision of the Census questionnaire to capture information on those with multiple residences at each address.
(b) Planned deployment of enumerator resource to secure a higher response rate (and hence a lower imputation rate) in those areas subject to most imputation in 2001.
(c) Completion of dummy forms early on during the enumeration window, rather than at the end as in 2001, leading to a more accurate estimate of how many missing households needing to be imputed, and where.

9.10 Our understanding is that ONS are still giving consideration to the precise use that will be made of late Census returns. We note their potential usefulness as donor records for the imputation of missed persons and households. We trust that any pre-imputation use of late returns in dummy record substitution will give consideration to the need for equal treatment of all LAs.

Recommendation 9.1: Finalise and publish details of the planned large CE imputation process in sufficient time to receive user feedback before it is implemented and describe in the final documentation how imputation deals with small CEs.

Recommendation 9.2: Identify areas and population sub-groups with significant overcount and assess the extent of any bias that might be introduced by retention of duplicates, through a comparison of identified duplicate and missed records.

Recommendation 9.3: As in 2001, publish imputation rates for each LA, age, sex, ethnicity and intention to stay category, so that expert users can take account of these when undertaking their own analyses of Census data.

10. Quality assuring population estimates for Local Authorities by age and sex

10.1 The Census-CCS estimate for each LA will be compared with a collection of alternative estimates of population size and structure. Every LA will undergo 'core QA'. If this indicates possible problems with the Census-CCS estimate, a set of more time-consuming 'supplementary QA' will be undertaken. If this confirms that the Census-CCS estimate can be improved upon, then adjustments will be made. (*ONS20*).

10.2 The decision to make an adjustment to the Census-CCS estimate for an LA will be taken by ONS after examining a range of comparator datasets, fieldwork intelligence and demographic analysis. In the case of incomplete or conflicting evidence, judgement will be used after thorough discussion by the QA teams, using expert knowledge relevant to the particular LA. The final population estimates will be signed off by the National Statistician.

10.3 Some QA is undertaken at regional or national level, which could lead to adjustments for many LAs. If and when adjustments are made after QA, then each LA affected will be returned for imputation of its revised level of net undercount, and the new estimates are quality assured again.

Variation in the quality of comparator datasets

10.4 The Census is, by its design, a better count of population than any other method. It is therefore a challenge to find other indicators of population that are so good that they reliably identify where the Census has failed. Administrative datasets tend to lag behind population change and to exclude some of the population. In discussion with ONS we agreed that it is useful to distinguish 'QA for improvement' which use the strongest available checks on the Census, from 'QA for explanation'.

10.5 *QA for improvement*: strong indicators of population, sufficient to replace the population totals or population characteristics in those areas where it is believed that the Census-CCS estimates are lacking.

10.6 In most cases these indicators can be used both to indicate a Census failure, and to provide the replacement figure. One such dataset already used for several decades is the estimate of infants under one year old provided by birth registration adjusted for infant mortality and migration. Similarly strong indicators are needed for the entire age range.

10.7 QA for improvement potentially includes the following, identified during discussion with ONS (*ONS21*):

(a)   For each LA and Lower Super Output Areas (LSOA) within them, (i) external alternatives: the address register after Census fieldwork improvements, to provide total households; birth registrations; Higher Education Statistics Agency data for large student residences; armed forces data for bases; School Census data and (ii) Census-based alternatives: DSE estimated with alternative strata; alternative LA estimation from borrowing strength from other LAs or alternative EAs, or using a local fixed effect estimate (see 8.4).

(b)   For areas larger than LAs, to establish patterns that would be applied to all LAs or types of LA: (i) the address register after Census fieldwork improvements, to provide total households (EA); and (ii) if justified after further research: the age-specific pattern of sex ratios constructed from the sample administrative records in the Lifetime Labour Market Database (regional/national); IHS linkage (regional/national); LS linkage for overcount and undercount (national).

10.8   *QA for explanation*: indicators of population that would normally not be reliable enough to replace the Census, but should (a) indicate the need for Census improvement if they all point in the same direction away from the initial Census estimates; (b) explain the nature and cause of Census failures in the cases where the Census does need improvements; (c) explain the nature of their own weaknesses, where the Census is shown to be reliable.

10.9   Most QA datasets proposed by ONS fall into the category of QA for explanation. Some may often be good indicators of population, such as the NHS counts of patients in each area, but whenever a discrepancy with the Census is found it is not possible to be sure that it is not largely due to a localised failure in the quality of patient registration rather than a failure in the Census. Others may be less good even in principle, such as the mid-year population estimates which have documented general inadequacies that await the Census to correct and replace them.

10.10   Some indicators duplicate each other. For example analysis of the level of fertility and mortality rates is based on the mid-year estimates and therefore is unlikely to show more than the mid-year estimates do. In this case, it is only unusual age schedules of fertility and mortality that are likely to provide additional power in the QA.

10.11   Individual matching of records from the CCS with NHS registrations or other administrative sources used in QA, will help to indicate the quality of each source by establishing duplicated and extra records. They may indicate the need to re-calculate the Census-CCS estimates using a different stratification. However, users should not hold out hope that these sources could replace the 2011 Census if it fails in particular areas, because they are not reliably accurate and complete.

Improvements since 2001

10.12   The evidence that can be drawn upon for QA, and the procedures for undertaking it, have been expanded considerably since the experience of the 2001 Census, when a structure of QA for each LA estimate was first put in place. (*ONS1*).

10.13   ONS is in a much stronger position than it was in 2001 to quality assure the Census population estimates. It will have operational intelligence from fieldwork in each LA, a larger range of administrative datasets with which to compare the Census, a range of demographic analysis checks, and

the capacity to undertake individual record-matching between the Census and other datasets when there appears to have been a problem in a particular area. A significant amount of the checking and analysis can also be undertaken not only for whole LAs but for smaller areas (LSOAs) within them.

10.14 The equivalent of the 'LA studies' that were undertaken between 2002 and 2004 and resulted in adjustments to the initial 2001 population estimates, can and will be undertaken within the QA before the 2011 population estimates are published.

10.15 Importantly, ONS accepts that it is likely that in some area or other there will be a need to make improvements to the Census-CCS estimates, and thus there must be accepted procedures to do so in place before the QA starts.

Concerns with QA

10.16 Council Tax, which was very helpful in the 2003-3004 LA studies (*ONS22*) will be available in the aggregate for QA, but not as individual records due to legal constraints. We encourage LAs to freeze relevant local datasets to reflect the population at Census day. This will be potentially useful in the QA, and helpful to the LA to understand the characteristics of their own datasets.

10.17 LAs, and indeed all users, have had the opportunity to suggest and offer datasets that would be of use to QA. We have not seen evidence of robust datasets that would aid QA that are not being used.

10.18 On the contrary, the number of QA comparators that are proposed is such that there are likely to be several discrepancies with the Census for each LA. How does one identify those discrepancies that indicate a failure in the Census from those that arise from a failure in the comparators to accurately reflect population? The ONS approach of tolerance ranges and thresholds for flagging multiple large discrepancies will usefully rank the discrepancies.

10.19 However, the criteria for moving from core QA to supplementary QA and to improvements are not well defined. The current proposed thresholds can be improved by taking into account the known variation in quality of the comparators.

10.20 We are not convinced that the criteria for Census improvement can be developed during QA as currently proposed (ONS20, section 3.4). In the heat of quality assuring Census-CCS population estimates for 348 LAs, faced with several dozen comparator datasets and a multiplicity of local circumstances and unforeseen hitches in Census fieldwork and processing, every aid to prioritising work according to criteria agreed by users will be helpful. Judgements will inevitably be required, but they should be minimised.

10.21 It is feasible to debate and establish priorities for QA now, but more information is required in particular about the methods proposed to improve the Census when necessary. In our view, the priorities for QA should be driven by the QA checks and comparators which are strong enough to be used in improvements to the Census (see 10.5 and 10.6).

10.22 QA checks and comparators that are not strong enough to be used directly in improvements to the Census should nonetheless be carried out as planned, unless time-consuming or essentially duplicating other checks. Their role will be as set out in 10.8 Explaining the weaknesses of these comparators will

be important both in gaining acceptance for the Census-CCS estimates, and in making best use of non-Census datasets in the following decade.

10.23 We are concerned that many items of QA are under development with significant work still to be undertaken or documented. Those with potential to be used directly in improving the Census population estimates if necessary, should be prioritised over work to complete aspects of QA that will not be used directly to improve the Census.

10.24 None of the potentially strong indicators proposed so far by ONS will indicate when a substantial number of adults is missed from counted households, if this is not captured accurately by the CCS and if it is variable between localities. The approach to deal with distributing regional or national evidence for missed people will need to be clarified more than is currently the case, and acknowledgement given to the professional judgement that may be involved.

10.25 A more convincing timetable for coverage assessment and QA needs to include time for contingencies. ONS identified the lack of time to deal with unforeseen difficulties as a major weakness in 2001 (*ONS1*). While the difficulties encountered in 2001 have been thoroughly examined and prepared for in 2011, the new procedures and new conditions of 2011 may well bring new unforeseen issues.

10.26 We are reassured that ONS plans to publish all QA material for each LA (except that restricted by confidentiality rules), in summary at the same time as the population estimates, and with further detail within three months. This will encourage acceptance by the major users of the Census outputs.

10.27 The process of QA, with an internal team undertaking investigative work, a panel to consider recommendations, and a high level panel including external members, before the executive panel headed by the National Statistician signs off the final results, is a clear improvement on the arrangements in 2001. The high level panel meeting each 6-8 weeks will include expert LA perspectives on London, Wales and more generally (*ONS20*).

10.28 The request from some users that ONS involve local expertise during QA when special investigations of an LA's results is deemed necessary in the QA, seems to be consistent with ONS practice in the LA studies after the 2001 Census.

(a) Documentation and consultation prior to QA

Recommendation 10.1: In the light of our comments, identify those QA checks that are so strong that they are able to be used to improve the Census where necessary.

Recommendation 10.2: Provide a unified overview and detailed documentation of proposed QA methodology as soon as possible to allow users to understand its coherence.

Recommendation 10.3: Undertake discussion in Spring 2011 to gain users' confidence in the QA and in the post-QA improvement procedures.

Recommendation 10.4: Confirm that knowledgeable, impartial support would be sought from the LA concerned during QA, when encountering a difficult and unusual pattern of discrepancies between the Census population estimates and detailed QA checks.

(b) Preparation and implementation of QA

Recommendation 10.5: Use the strength of each QA check to prioritise QA work, giving low priority to work-intensive checks that are unlikely to be used in improving Census estimates. This priority should apply both in the current preparation for QA before summer 2011, and during the subsequent QA itself. In particular, the proposed procedures and datasets for post-QA improvement should each be fully specified and fully prepared prior to their use in QA. This does not preclude judgement and methodological refinements during the QA.

Recommendation 10.6: Prepare for and expect to undertake supplementary QA in LAs with the highest indications of concern from the HtC index and field reports.

Recommendation 10.7: Ensure that the timetable for coverage assessment and QA is sufficient for the likely requirements of in-depth investigation for a minority of LAs as well as the national investigation that can only be finalised when all LAs have been processed.

11. Quality assuring population estimates for Local Authorities by ethnicity

11.1 The CCS will record ethnicity in ten ethnic group categories (collapsing the four White categories, the four Mixed categories, and the two Other categories, and not including a Chinese category). The CCS and the Census will be used to create DSE estimates of the full population for each LA, when stratified by the ten categories of ethnicity. This will establish the distribution of ethnicity within the total population already estimated from DSE using age-sex categories (see 5.5). The imputation process will provide the full 18-category ethnic group distribution for those missed by the Census.

11.2 Proposals for QA of the ethnic group distribution use comparators which we think are not sufficiently robust estimators of the resident population with which to judge the Census-CCS estimates and their ethnic composition.

   (a) ONS rolled forward mid-year ethnic group population estimates assume that the ethnic dimension of migration patterns within the UK have remained constant throughout the decade as estimated for 2000-2001, which is highly unlikely. Rolled forward ethnic group population estimates for mid-2011 are unlikely to identify a weakness in the Census that other comparators have not already indicated. They may be needed in order to assess and improve the production of estimates between Censuses.

   (b) The IHS can provide national estimates for 2011 of detailed ethnic group, regional estimates of broad ethnic group, and White/Other dichotomous estimates for larger EAs. However, response to the IHS is considerably lower than expected in the Census, and is likely to be worse for some ethnic groups (as it was in the 2001 Census: *ONS17* Its estimates are likely to be more biased than those of the Census.

   (c) The School Census will provide only a lower bound for compulsory school ages 5-15, as it excludes those not in state schools. Its categories are not the same as in the population Census, and there

may be cases of systematic local mis-recording. This suggests that the School Census is unlikely to be trusted as an adequate substitute for the Census' ethnic composition.

11.3   We cannot identify administrative or other data sources with stronger indicators of the ethnic composition of the population. The published Census population estimates will rely on the general QA to identify areas where an ethnic group has particularly low response rates.

11.4   The QA indicators may be of use to confirm the DSE estimate based on ethnic group stratification, if it shows greater undercount for particular groups than does the DSE estimate based on age-sex strata.

Recommendation 11.1: The QA indicators for ethnic group should not be considered for adjusting the Census.

Recommendation 11.2: The plans to target large households and HMOs in early collection should be as comprehensive as possible. Where ethnically diverse LAs with substantial numbers of recent immigrants have not provided lists of HMOs for targeting by early collectors, these lists should be sought with urgency, targeted in those LAs for which published numbers of HMOs are high.

12.   How will the problems of 2001 be overcome before the Census population estimates are finalised?

12.1   The table below directly addresses concerns arising from experience after the 2001 Census. The second column identifies what was done after 2001 to address the issues. These mostly occurred as revisions after LA Studies during 2002-2004, when the population estimates for Manchester and Westminster were raised by 26,200 and 17,500 respectively, and those of thirteen other LAs were raised by smaller but significant amounts.

12.2   For 2011, the third and fourth columns identify how each problem will be minimised or dealt with before population estimates are published. This summary is not intended to be comprehensive.

Problem identified in 2001	What was done to improve the 2001 population estimates?	What will be done to prevent the problem occurring in 2011?	What will be done to deal with the problem if it nonetheless occurs in 2011?
An inaccurate address list for the Census, out of date and excluding many multiple flats in houses.	The list for enumeration was based on the 1998 Postcode Address File (PAF). Comparison to Council Tax registers was undertaken for the later revisions.	The address list has been created from the PAF and the National Land and Property Gazetteer, each updated to December 2010, plus information about new developments. It is expected to include at least 99.2% of properties nationally. Coverage will be higher in the 15% of areas included in the 2010 address check and where field checks of HMOs take place in 2011 according to lists provided by LAs. The updated list is then further improved by Census fieldwork itself.	Comparison will be made with Council Tax registers during QA, including record-matching if possible.
Localised enumeration failure	Understood in later revisions, corrected with Council Tax registers as above.	Response rates and collector information for non-responding addresses will be monitored, and resources re-directed during enumeration. Student and seaside areas will be prioritised at the start of the CCS.	Fieldwork intelligence will identify poor response for LSOAs and the improved address list can be used for a count of households.
Many thousand late-arriving forms were not processed	These were identified and used to help later revisions	There will be a longer follow-up window and fieldwork will be targeted at non-responders, so late returns reduced.	Late-returned forms may be used during imputation if the volumes are large.

Problem identified in 2001	What was done to improve the 2001 population estimates?	What will be done to prevent the problem occurring in 2011?	What will be done to deal with the problem if it nonetheless occurs in 2011?
The HtC index used in estimation was sometimes inaccurate	Based on information a decade old, inaccuracies were identified and partly corrected in later revisions through re-stratifying using 2001 Census.	Based mostly on information from 2009.	Re-stratifying DSE estimation will use 2011 information, for example fieldwork response rates, during the QA, if shown to be more useful than the HtC index.
The sample in the CCS was sometimes unrepresentative	When CCS postcodes were shown to be unrepresentative of response, corrections were made in later revisions.	This cannot be avoided during the Census.	Field information on Census response rates will be used where necessary to post-stratify the ratio estimation [*ONS20* section 5.2.2].
Insufficient fieldwork management information to identify enumeration failure and help in estimation	The limited information available was used during estimation. Other information was available later and used in later revisions.	The questionnaire tracking system will provide daily response rates for each enumeration district to enable coordinators and area managers to deploy field staff where response rates are lowest, and enable census HQ to allocate additional resources Dummy forms will be completed earlier than in 2001	If response rates are lower than expected then additional CCS sample will be deployed. Field Information including Census (and CCS) response rates will also be used to inform the QA
Administrative data sources used for QA were insufficient to be sure that the Census was at fault	Adjusted address counts for regions were used in the estimates, and Council Tax registers were used in later revisions.	After extensive investigation, there is still no administrative data of sufficient quality to replace population counts from the Census.	Adjusted address counts will be used in estimates for EA and where necessary for LAs and smaller areas, as will students and armed forces in large establishments, and infants under one.

13.   Can the Census weather the perfect storm?

13.1   Many difficulties for the Census are caused by inaccessible housing, residents who do not live in a stable household, a diversity of languages other than English, and irregular working patterns. It is not unusual for these circumstances to coincide in the same area. Can the assessment of coverage cope with the 'perfect storm' of coinciding challenges?

13.2   Suppose an LA has many overseas immigrants of diverse origins residing for only a short period in the LA before moving to a more settled location, and substantial numbers of students whose address out of term-time is elsewhere, and many large houses divided into flats without easy access, some of which are rented to those who work but do not live permanently in the area. Suppose that recruitment of Census fieldwork staff in the same area had been successful but that more than one local team do not diligently follow up non-respondents.

13.3   Without repeating all of the key improvements identified in section 2.2 to address particular enumeration challenges, or the solutions summarised in section 12, what would the main saving strategies be for the production of robust Census population estimates in such an area?

13.4   Before Census day, 'early Census Collectors' will visit the precise location of HMOs known to the LA, to check and correct the address list and to leave appropriate numbers of extra forms. After Census day, the number of Census Collectors allocated to the LA will be 3-4 times greater than in 2001, because it will have been identified with a high HtC index (Townsend, 2011).

13.5   Due to the new Census questionnaire tracking system and a service level agreement with Royal Mail, a low household response rate would be apparent to Census managers and to ONS centrally in the morning of day 10 after Census day, when follow up collection begins, and thereafter be updated daily. Dummy forms for all non-responding households are required from Census Collectors during days 8-14 after the start of follow-up. If specific areas encounter low response or poorly completed fieldwork, the local Census co-ordinators and manager will redirect Census Collectors, whose contracts stipulate availability to work throughout an LA. Extra hands can also be gained by an increase in hours from part-time Collectors as successfully trialled during the Census rehearsal. Recruitment procedures stipulate rapid replacement of Census Collectors who drop out, by trained Collectors within 72 hours of a request.

13.6   A Census response rate of at least 80% in each LA is a challenging target. ONS will know centrally if and where this is likely not to be achieved, in time to target additional CCS sample in those low response areas.

13.7   An LA may nonetheless have less than 80% Census response, implying that more than 20% of Census household records will have to be imputed. There will certainly be neighbourhoods of sizeable population, say more than 1000, with response rates considerably below 80% and, in the 'perfect storm', response may well be lower than 50%. Good Census population estimates will then depend on Census coverage assessment and its QA.

13.8   The Census-CCS estimates will be able to estimate the relatively large non-response for such an LA. Alternate strata for DSE and a fixed-effects estimation of the LA within its EA as discussed in sections 5

and 8 will be considered to reduce the confidence interval around the Census population estimates, which will also be relatively large because of the low Census response.

13.9 It is quite possible that, in the difficult area imagined for this section, there are many households and individuals who are especially difficult to enumerate in the CCS and the Census, whether by avoidance or because of irregular living circumstances. In this case the 'bias adjustment' procedures described in section 5 will be essential to improve the Census-CCS estimates.

13.10 During QA, a large number of checks will point to LAs and neighbourhoods that may not have been estimated well. A number of datasets will improve the Census-CCS estimate for this LA. Administrative data for CEs, including student residences, will fill up holes if they are seen to exist, but will not be suitable for individuals missed from enumerated households.

13.11 Student areas will benefit from an analysis of second address information, at their out of term time residence (their family home), to supplement the number of students in households.

13.12 For the household population of the LA and the neighbourhoods within it, QA to improve the Census-CCS estimates will rely heavily on the Census address register, refined during the fieldwork and with updates from address product suppliers. It will not however be used without investigation, during QA, through comparing Census and address register information to health service and Council Tax information for neighbourhoods that are suspected to be particularly poorly enumerated.

13.13 These methods of checking and improving the Census give confidence that the resulting final Census population estimates will be better than any other method and will be suitable for use in resource allocation and planning. To the extent that Census fieldwork does not meet its targets in some areas (see 2.3), however, the size of the population and its characteristics will be imprecisely known, and the Census output a less reliable indicator of real needs. ONS' plans to accompany the final Census estimates with details of the QA are reassuring, for they will allow users to be more confident in their appropriate use.

Appendix 1: Terms of Reference

Independent Review of Coverage Assessment, Adjustment and Quality Assurance

Terms of Reference

Introduction

One of the recommendations from the recent London Regional Select Committee was the need for further independent assessment of the methodology to assess, adjust for coverage error in the 2011 Census and quality assure the 2011 results. In addition, discussions with LAs have indicated a very similar need for a review of the methodology which will deliver a set of census estimates that will be the benchmark for future population estimates and hence resource allocation.

The use of the population estimates in resource allocation is a key driver for the development of the methodology for census coverage assessment, adjustment and quality assurance. Its strategic aim is to produce a set of robust census population estimates for local authorities and for key population groups (five year age-sex groups, BME populations) in which users have confidence.

The terms of reference set out here for a methodology review will action these concerns and provide ONS with a valuable opportunity to take stock and identify any remaining areas of risk whilst there is still time to mitigate and develop contingencies for these risks.

Objectives

The objectives of the review are to:

- To provide independent assurance and thus confidence to users that the methodology to produce the census population estimates is based upon sound research and a strong evidence base.

- Identify areas of the process or methodology that can be significantly improved;

- Identify the main risks with the methodology, noting any particular problems/challenges the methods will need to be able to deal with, and any further work required to mitigate these risks and challenges;

Scope

The table below outlines key processes and methodological areas that are used in the production of the census population estimates and detailed population characteristics and identifies those areas which are in scope for the review. Necessarily some items are out of scope due to limitations in the timetable for making changes. However documentation on these aspects will be available to ensure that the reviewers have a complete understanding of the methods.

Methodological area	In or out of scope
Census and CCS fieldwork methods	Out
CCS Questionnaire	Out
Sample Design of Census Coverage Survey	Out
Definition of the Hard to Count Index used in coverage adjustment (excludes non-response model used in field allocation)	Out
Census and CCS Matching	In
Estimation methodology	In
Dual system estimate bias adjustments	In
Estimation and adjustment of overcount	In
Imputation of persons and households	In
Imputation for question non-response	Out
Quality assurance of the Census population estimates	In
Contingency plans for census population estimate modification	In

The review will focus on the methodology being developed and implemented by ONS for England & Wales.

Reviewers

It is expected that no single person will have the expertise or experience required to conduct the review alone. Therefore it is expected that a small team consisting of two or three experts will conduct the review.

The review team will need the following experience and expertise:

- Sample survey statistician
- Demography and, specifically, population estimation, migration estimation, and estimation of specific population sub-groups
- experience in the application of census population estimates, particularly in local or central government

Understanding user concerns

One of the main drivers for the review has been the concern expressed by some users, particularly LAs that the methodology is not robust enough to deal with the enumeration challenges that are specific to a small number of Local authorities. This includes particularly high concentrations of migrants, short-term and long-term, an ethnically diverse population, and particular types of housing. Therefore the review team will need to understand these concerns.

A mechanism for gathering these views will be initiated by ONS, which will then feed directly into the review team. ONS will work with key organisations that represent LAs to gather and channel user concerns into the

review team. The bodies likely to be involved are the Local Government Association, the London Councils, and the core cities group; the latter a group of LAs that represent the main urban areas of England & Wales.

Timing

The entire review should be completed by the end of January 2011, with a report delivered to ONS. Publication of the report will follow in early February. An indicative timetable for the review is detailed below which reflects the different development timetables for the methodology and the relative complexity of the different aspects.

October to November*

- Understand key lessons learned from the 2001 Census, and how these have influenced the 2011 Census design.
- Gain an understanding of the high-level design of coverage adjustment and quality assurance and how all the components fit together.
- Review detailed methodology for coverage assessment and adjustment.
- Receive and review user concerns about the methodology.
- Produce report on emerging findings

December to January 2011*

- Consider the more detailed quality assurance methods.
- Review the proposed methodologies for adjusting the census estimates as a result of expected breaches in the assumptions underpinning the methodology.
- Produce a report summarising the findings of the review.

* dates are indicative

Liaison with ONS

The review team will need to have frequent access to ONS to help understand particular aspects of the work, request further information and report on progress. The key contacts at ONS will be:

- Peter Benton – Deputy Director, 2011 Census – overall responsibility for the review.
- Garnett Compton – Head of the 2011 Census Design Authority – manage contract, liaison with the review team and the supply/exchange of information.

Appendix 2: Local Authority consultation

The following three questions were submitted to the LA organisations listed below:

1. Do you consider there to be particular population groups at risk of underestimation in the Census population estimates?

2. Does the QA process make use of the most relevant datasets to adequately assess the plausibility of the Census population estimates?

3. What do you perceive to be the most significant risks with the methodology?

LAs were consulted via:

1. Core Cities Authorities

2. Local Government Association

3. Greater London Authority

4. Local Government Data Unit, Wales.

References

Brown, J. Abbott, O. and Diamond, I. (2006) Dependence in the 2001 one-number census project. *Journal of Royal Statistical Society, A,* 169, 883-902.

Steele, F., Brown, J. and Chambers, R. (2002) A controlled donor imputation system for a one-number census. *Journal of Royal Statistical Society, A,* 165, 495-522.

Townsend, N (2011) Field design: getting the numbers right, *Population Trends (in press)*.

All the material referred to as *ONS 1* up to *ONS22* can be accessed via the following web link:

www.ons.gov.uk/census/2011-census/2011-census-project/independent-assessments/special-assessment-of-the-2001-censuses-in-the-uk/references-for-independent-review-of-coverage-assessment--adjustment.doc