# Are the census outputs fit for purpose?

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## Introduction

The Census provides a very large array of statistical output with unique local detail, uniquely cross-tabulated social, employment, health and demographic detail, which is mostly comparable across the UK and comparable with previous censuses. It is clearly fit for many *macro-administrative purposes* of distributing central and local government resources appropriately to areas of need; it allows public and private investment to be targeted efficiently. It also provides a basis for *policy evaluation and research* for which there is no substitute in the UK. However, the limited questions that can be asked in an enumeration of the whole population, and inevitable weaknesses in the quality of that enumeration, make it less fit for some purposes than others. The census has not been intended for *micro-administrative purposes* – the determination of either services to individuals or responsibilities of individuals – which would have major political consequences affecting the feasibility of a census.

The quality of a research tool such as the census can be assessed in many ways. It should have a defensible, documented design, be rigorous in its conduct, provide credible and verified results, and contribute new knowledge about the UK for useful purposes[1]. The 2001 census has been questioned on all four of these criteria. It has been said that the design to cope with contamination between the Census and its coverage survey was faulty from the start and patched up at the end; on conduct, the commercial contracts including that with the Royal Mail were far from rigorous; the credibility of some of the results has been questioned because of their uncorroborated implications for international migration; finally the fitness of the data for small areas has been questioned because of non-response and the adjustment of small numbers before publication.

This paper addresses these particular concerns, firstly by examining the performance on the important aim of reducing the differential undercount between groups of the population. Secondly the paper quantifies the impact of adjustment of small numbers and discusses the accuracy of data for small areas. Finally the paper reviews the quality assurance of the One Number Census and ends with conclusions[2].

## Differential undercount

No census counts 100% of the population. However, the use of the census to compare different areas, and to distribute resources on the basis of those comparisons, requires reliable results in all areas. Difficulties after the 1991 Census led the Office for National Statistics (ONS) to establish in 1997 a Steering Committee to oversee a new strategy, the One Number Census (ONC). In its first papers it accepted that "The priority for the development of the 2001 Census is to ensure that the maximum possible coverage is achieved, and in particular that the differential nature of any underenumeration is minimised. To this end, the methodology for carrying out the Census is being re-assessed; to reduce the burden on the public and to use resources to

their best effect."[3] Higher undercount in some areas jeopardises estimates of population characteristics in those areas, reducing fairness when using the census to distribute resources. This aim was re-iterated to the Treasury Committee four years later, after the enumeration: "The key to our whole strategy has been to try to minimise the amount of differential undercount."[4]

It is not clear how ONS would define differential undercount. Presumably the desired outcome would involve some levelling up of the response rates, so that they are more equal and higher in hard to count areas than they would have been without the strategy. Some critics felt that improvement in hard-to-count areas is impossible and that this focus would only level down quality, by taking resources from easier areas.

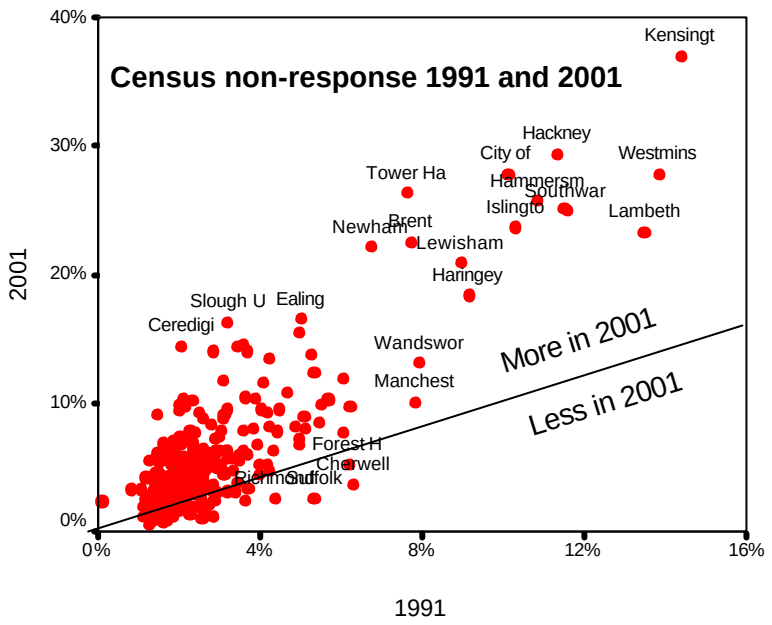
Many ways of encouraging response are well-practised in the UK Census, including high-profile publicity, carefully designed forms, testing and rehearsals. In 2001 the field force was cut by one third compared to 1991. In all easier areas, most areas, enumerators had two Enumeration Districts to cover. To make the job possible, forms were returned by post, and enumerators were to focus on those households that had not returned their forms. In these ways, Census Managers were to focus their resources on areas that were traditionally hard to count.

Postback was taken up by over 80% of households. Unfortunately, the Royal Mail didn't process the forms fast enough for Census Managers to know who had sent them back. A doorstep a response of "I sent it back ages ago" had to be believed whether true or not. "The Post Office problems were largest difficulties that we faced in the conduct of the Census."[5] ONS were powerless to intervene as they had no contract with the Royal Mail. Enumerators and their local managers suffered frustration and extended workloads that were a major contributing factor to putting the census £9million over budget in July 2001[6].

Forms that are posted back cannot be checked on the doorstep. Enumerators were asked to return to households only if the form did not have valid answers for age, sex and marital status of each person listed at the front of the form.

*Person non-response*

There was an impact on the quality of the returned forms. How much impact? The figure shows the 2001 response rates for each local authority district, compared with that for 1991, using comparable definitions and boundaries[7]. In general, areas that had high undercount in 1991 had even higher undercount in 2001. The mean undercount was higher than in 1991, and the geographical spread of non-response was greater in 2001 than in 1991, whether measured by range, standard deviation of the ratio of standard deviation to mean. The age-sex profile and characteristics of non-respondents estimated by the census validation surveys in 1991 and 2001 suggest that those most likely to be missed have similar profiles: young adults and those who are in some sense unsettled or socially excluded – unemployed, renting privately or recently migrated. However, a somewhat broader cross-section has been missed in 2001 than in 1991.




Source: see text

*Item non-response*

Returned forms also have missing or invalid or inconsistent answers to some questions, the 'item non-response' summarised in the box below. Only the three questions checked by the enumerators were missing on less than 1% of forms. In every other question the item non-response was more than in 1991, when most questions had non-response under 1%. Religion was voluntary in 2001, but achieved over 90% response. There was some variation between areas. If one takes 5% non-response as poor, the four best districts had poor response for only four questions (Wokingham, Eastleigh, Hart, E Dorset) while seven Districts had poor response for over 20 questions (Manchester, Blackburn and 5 London Boroughs)[8].

ONS filled in these missing items using information that was on the same form and on other similar forms. On that basis they corrected the biases that would have occurred, which they found to be "in the same direction as those present in the 1991 Census, but were less marked."[9]

**Item non-response: missing, invalid, inconsistent responses, England and Wales, Census 2001**

| | |
|---|---|
| **Under 1%:** | age, sex, marital status |
| **1-5%:** | country of birth, ethnic group, health, long-term illness, address one year ago, economic activity, occupation, relationship to person 1, accommodation type, self-contained, bath/shower, lowest floor level, central heating, cars, tenure |
| **5-10%:** | religion, provision of care, qualifications, employment status, supervisor status, industry, workplace address, hours worked, travel to work, number of rooms |
| **More than 10%:** | Professional qualifications 17%, company size 14% |

In summary, for both missing people and for questions unanswered on returned forms, there was lower response in 2001, there were higher geographical differentials, and a more general cross-section of people were affected. The fieldwork strategy was not successful in minimising differential undercount. There was no levelling up of response rates as hoped, nor a levelling down as feared. Instead, response is lower all round and more so in the areas which already had low response in 1991, in spite of the attention to hard-to-count areas. The impact of postback on the quality of response requires further review before it is used again or extended. We need means of ensuring accurate results in areas difficult to enumerate.

It has to be stressed that the ONC filled up all these gaps with estimated data. The published tabulations do not suffer from differential undercount (with the exception of the extra undercount estimated since 2002). That is the success of the ONC as argued by most users of census data. However, our confidence in the accuracy of the data should be less in the areas with greater undercount; in those areas more estimation has been undertaken, which makes the published results less secure. ONS have published confidence intervals for the populations in each local authority district. I will return to the confidence in the population totals in the third section of this paper.

**Disclosure control – its impact on quality of census data**

Various measures are in place to protect personal information from disclosure in census output. Output areas have minimum size; some variables have broad categories; the inclusion of imputed records makes it harder to know whether the census output relates to real households; some records are swapped between areas.

In 2001, ONS took a new and stronger attitude to disclosure control. It resulted in both Samples of Anonymised Records losing geographical detail. The final specification of the Samples of Anonymised Records is not yet available but it is clear that the success of their introduction in 1991 will be reduced, as aspects of household structure and geographical patterns that were important to 1991 analyses are not available for 2001.

*Tabular output*

In tabular output for areas, small numbers are adjusted to eliminate all 1s and 2s by altering them to 0s and 3s such that no bias is added on average. For example, the national report shows no health professionals in the English fishing industry; it means that in the census database there may in fact be none, or 1 or 2 such records. According to the census output, there are 400 prisoners in Birmingham but no prisons. As in previous censuses where a different kind of adjustment was used, the table totals are the sum of their rounded cells. Since tables are rounded independently, the number of ill people, say, will take different values in each table it appears[10]. The adjustment procedure has not been adopted by the Census agency in Scotland, where the Registrar General feels that the risk of disclosing personally identifiable information is not sufficient to warrant the cost and impact of adjusting the census data in this way. The exact procedure used in England, Wales and Ireland is not published, because knowledge of the procedure would help to recover a limited number of the 'true' 1s and 2s.

The adjustment of small cells affects the value of the data. Inconsistent tables are inconvenient in analysis and present a psychological barrier for casual users of the census. To what extent do they also add inaccuracy to the data? What should users beware of?

*An example*

The box below shows part of the Census Standard Table 28 where one would normally go to for an unemployment rate; one has to go to this table for an unemployment rate among those of working age which is the usual measure for unemployment. The table here is for Grassington ward in North Yorkshire. The full published table is extended downwards to include male and female age groups, and rightwards to include other economic activity categories.

**Part of Standard table ST028, Grassington ward, North Yorkshire**

| Grassington | ALL PEOPLE | Economically Active | Employee: Part-time | Employee: Full-time | Self-employed (with employees): p/t | Self-employed (with employees): f/t | Self-empl (without employees): p/t | Self-empl (without employees): f/t | Economically Active: Unemployed |
|---|---|---|---|---|---|---|---|---|---|
| ALL PEOPLE | 1,102 | 729 | 148 | 293 | 15 | 71 | 42 | 120 | 21 |
| 16 | 13 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 10 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 12 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 19 | 13 | 13 | 0 | 7 | 0 | 0 | 0 | 3 | 0 |
| 20 to 24 | 42 | 39 | 8 | 25 | 0 | 0 | 0 | 0 | 3 |
| 25 to 29 | 45 | 39 | 4 | 23 | 3 | 0 | 3 | 6 | 0 |
| 30 to 34 | 63 | 58 | 13 | 26 | 0 | 5 | 6 | 5 | 3 |
| 35 to 39 | 100 | 90 | 24 | 36 | 0 | 10 | 3 | 17 | 0 |
| 40 to 44 | 93 | 81 | 14 | 35 | 3 | 3 | 9 | 17 | 0 |
| 45 to 49 | 103 | 97 | 17 | 47 | 3 | 13 | 3 | 8 | 6 |
| 50 to 54 | 136 | 115 | 23 | 50 | 0 | 17 | 3 | 19 | 3 |
| 55 to 59 | 133 | 97 | 24 | 28 | 0 | 12 | 6 | 27 | 0 |
| 60 to 64 | 111 | 40 | 14 | 10 | 0 | 5 | 4 | 7 | 0 |
| 65 to 69 | 136 | 38 | 7 | 6 | 6 | 3 | 5 | 8 | 3 |
| 70 to 74 | 92 | 6 | 0 | 0 | 0 | 3 | 0 | 3 | 0 |
| Males | 526 | 375 | 22 | 169 | 3 | 55 | 14 | 94 | 9 |
| 16 | 8 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 9 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |

The total number of unemployed is given as 21, big enough not to be adjusted if it were not the sum of 30 values for each male and each female age group; all of these 30 values are 0 or 3; each may have been truly 0 or 3 or may have been 1 or 2, meaning that the value of 21 unemployed is approximate. The unemployment rate is the number of unemployed divided by all those economically active, 729, which itself is a sum of 390 cells, about half of which are 0 or 3 and may have been modified.

The unemployment rate for this ward is 2.9% (21/729) but the rate on the census database itself can be expected to be 0.6% away from this figure in unknown direction (2.3% or 3.5%). This is the expectation, not an extreme possibility.

The equivalent table for census Output Areas is of greater concern. When values are computed for a neighbourhood as the sum of several wards or Output Areas, the number of adjusted small cells included in the sum increases rapidly. The impact on indicators used for targeting resources is to scatter them away from the values on the census database, and needs careful investigation.

*Advice*

What can users do to minimise the impact of adjustment of small numbers, given that it has been done? Some have suggested replacing all 0s and 3s by 1.5 which is closer to both 1 and 2. This is not advisable. It will add error: some of those 0s and 3s are true 0s and 3s.

One can and should advise on the likely size of error added by adjustment. The expected error added by adjustment in a census value that is the sum of several independent cells can be computed as follows[11]:

Expected error from small cell adjustment in a census value X =
0.8*Sqrt(n) where n is the number of 0s and 3s summed in the value X.

Thus the number of unemployed computed from the sum of 30 cells all of which are published as 0 or 3 can be expected to be in error by 0.8*sqrt(30)=4.4. We cannot tell whether the true value is more or less than the published value, nor whether in a particular case the error is more or less than this expected value. From similar calculations, in 10% of cases the error will be equal or greater than twice the expected value:

In 10% of cases, the error in a census value X will be greater than
1.6*Sqrt(n) where n is the number of 0s and 3s summed in the value X.

The only assumption made in these calculations is that half of the published 0s and 3s were adjusted from 1 or 2. This assumption is approximately true in the great majority of cases. It is not true for tables where most cells are true zeroes, such as the Special Migration and Workplace Statistics, but here the impact of small cell adjustment will be very great. For example, the majority of migration flows of at least 1 migrant in the 1991 ward migration statistics were either 1 or 2; when these are randomly replaced with 0s and 3s there is a drastic reduction in fitness for purpose[12].

In many cases, this level of error is not a problem, but users must be careful in particular when using ratios or percentages based on census output that involves adjustment.

Despite ONS assurance to the contrary[13], statistical analyses and significance tests are affected. The variance of all census output is increased by measurement error and the correlation between variables is decreased. Significance tests are affected. Experiments show that one fifth of statistical significance tests would change their conclusion – crossing the 95% confidence line – when comparing ethnic groups' local employment rates[14].

Further advice should be given:

- Where an indicator can be computed from different tables, use the summation of the fewest cells to avoid rounded values. Use data from Univariate and Key Statistics where possible.
- For percentages, pick the denominator from a different table than the numerator if it reduces the number of rounded cells involved.
- Do not compute a ward indicator from the sum of Output Area values, go direct to the ward table.

- If a neighbourhood is not quite a whole ward, subtract the missing Output Areas from the ward value rather than sum many Output Areas.
- Measure the expected error using the rule 0.8*(number of 0s and 3s); investigate and publish the possible impact on interpretation of results.

Much of this advice is as Keith Cole gave in 1991 for the different kind of modification used then[15]. The impact of modification in 2001 is often much less than in 1991 because it affects only small numbers. From the computations above, the impact is greater in 2001 when a fifth of the published cells are 0s and 3s. This does occur in many tables for wards and output areas, not just the one we have seen.

*Accuracy of local census output*

If this advice is useful to avoid errors in census analysis, then we need further advice that only ONS can give: what is the impact of all the various sources of error, including imputation and response error?

When ONS provides estimates of the quality of census data, it is the likely distance of the published data from the true picture that users require. Such guidance will need to be sensitive to the greater errors in smaller populations, for some questions and where there was greater imputation. This information is not trivial to compute, but it is essential for appropriate use of the census data.

This information on the accuracy of the One Number Census published results is also key to thinking about the quality needed from future censuses. Imputation was intended to reduce error, compared to the census enumeration. This will not be true for smaller populations, since the relative confidence intervals around published output increase as the population decreases. Another version of this question is: How good does enumeration need be to make the imputation worthwhile? It may be that simpler alternatives to the ONC, such as that used in 1991 where information from enumerators alone was used in imputation, would be better for smaller areas.

These calculations would avoid erroneous conclusions from the data, and give further useful evaluation of the benefits of the One Number Census approach.

## Quality assurance of the One Number Census

The One Number Census was carried out according to an agreed strategy, filling up the holes in the census database of 48.8m enumerated residents with extra records for those estimated to have been missed, 3.2m in England and Wales. However, this total – the One Number Census (ONC) population estimate for census day of 52.0m published in September 2002 – was still 1.1 million adrift from the expected population based on births and deaths and migration as monitored in the 1980s and 1990s. The ONS characterised the ONC figures for the countries of the UK and for local authorities as the best possible that can be produced.

The evidence to validate the ONC results depended on procedural assurances (that the ONC methodology had been carried out as agreed without failures), and on an independent household count whose incorporation into the strategy had been neither published nor shared with the Steering Committee or users, and which had not been

documented. This aspect of the census validation added 230,000 to the population in England and Wales before it was published in September 2002 and is included in the 3.2m ONC estimate of undercount.

ONS efforts to supply the demand for detailed information about the estimation procedures have continued during the twelve months since September 2002, in parallel with major reviews of international migration and the population estimates themselves. Both the Local Government Association and the Statistics Commission have published reports responding to concerns from local authorities[16]. ONS itself concluded that the undercount had been under-estimated by the ONC, adding a further 0.2m persons to revised estimates in September, and suggested that further research on the completeness of the census address lists may cause a further upwards revision to the mid-2001 population estimates[17].

I cannot hope to do justice to these reports in this paper. Instead I wish to highlight the significance of the assumptions that were made in the process and draw some conclusions for the fitness of the population estimates for their intended purposes, also looking forward to improvements. It is convenient to discuss the national estimates and then the sub-national estimates, while remembering that a change to either impacts on the other.

*National population estimates*

The table below summarises the evidence that contributed to the England and Wales population estimate after the 2001 Census, and has explained a discrepancy between it and the estimate rolled forward from previous census years.

I have categorised the judgements that are always found in population (and other) estimates. No evidence is complete, nor completely accurate. The judgements may be wholly informed by relevant evidence so that the possible errors will not be significant. They may be partly reliant on assumptions which if not correct would significantly affect the results. Or they may be mainly reliant on significant assumptions. This is the meaning of 'light', 'medium', and 'heavy' categories that I have used in the final column. They are themselves judgements, but I believe the relative weight of assumptions lying within the components would be generally agreed.

For example, the dual system estimate of undercount relies on the assumption of independence between the census and its coverage survey, a heavy assumption that is never likely to hold true as there are good reasons why some people will be hard to count by both instruments. That this was the case in 2001 is shown by the subsequent additions of 230,000 and 193,000 extra residents. In this sense, the independence assumption of the dual system estimate has been overcome, and is therefore shown in brackets in the table. The two revisions to it incorporate their own medium judgements which are well documented in the reviews cited above. They involve reliance of survey-based household estimates for a national level address count, assumptions for the size of the extra missed households, stable attrition rates over three decades for the Longitudinal Study, and assumptions for the sub-national distribution of these two additions which are plausibly directed at a minority of local authorities but use no quantified evidence. Where the assumptions do not hold precisely, and there will certainly be some areas where they do not hold well at all, the

**Components of the mid-2001 population estimate and its discrepancy with the mid-2001 population estimate rolled forward from previous censuses**
England and Wales

| | Component of population estimate | | Evidence | Judgements |
|---|---|---|---|---|
| *September 2002: the One Number Census* | **Enumerated residents** | **48,843,000** | | |
| | Dual system estimate of undercount | +2,968,000 | Census Coverage Survey | (Heavy) |
| | Revised estimate of household undercount | +230,000 | Addresspoint with LFS | Medium |
| *Sept 03* | Revised estimate of persons undercount | +193,000 | Longitudinal Study | Medium |
| *03/04* | Further revised estimate of household undercount | ? | Address matching in Mcr and Westr | Medium |
| *Oct 02* | Census day to June 30 | +43,000 | Births, deaths, migration | Light |
| *Sept 03* | **Mid-2001 estimate** | **52,277,000** | | |
| *Sept 02* | Unmonitored int'l net emigration 81-91 | +351,000 | 2001 census | Heavy |
| *July 03* | Unmonitored int'l net emigration 91-01 | c109,000 | Improved method applied to 91-98 | Light |
| | | c84,000 | Visitor switchers | Medium |
| | | c116,000 | Migrant switchers | Heavy |
| *Residual* | Unattributed difference from rolled forward MYE 2001 | +291,000 | 2001 census | Heavy |
| | **Mid-2001 estimate rolled forward from 1981** | **53,223,000** | | |

Sources: Census output (October 2002); ONS review of international migration (June 2003); ONS revised international migration estimates (July 2003); ONS revisions to the Mid-2001 population estimates (September 2003).

distribution of over 400,000 people to less than 100 local authorities within England and Wales will cause errors in some areas of 5-10,000 people.

There may be further additions to the estimate of undercount when the ONS address-matching exercises in Manchester and Westminster are complete early in 2004. This work is path-breaking and promises to improve the use of address lists in surveys, censuses and administration, and is expected to help gain agreement on population estimates in those two districts. The work nonetheless involves assumptions and errors that all concerned are well aware of. The agreement of a final figure will carry considerable uncertainty around that figure, as will any allocation to other areas that have not been part of the focused research in these areas.

Only the components of change from census day to mid-2001 rely on good evidence for each local authority area. Paradoxically, this is the component that relies not on the census but the intercensal methods that the census updates. However, the component is small in total and measured separately in each local authority, and in this sense involves judgements that carry light consequences relative to the other components in the table.

*Discrepancy with the population estimate rolled forward from previous censuses*
The remainder of the table refers to research seeking to explain why the mid-2001 estimates based on the 2001 census and subsequent revisions still differs from the estimates rolled forward from previous censuses by 946,000. This is important, since the methods of rolling forward from a census are used to provide us with population estimates through this decade. If reasons for their errors before 2001 cannot be found and corrected, then not only are the methods for this decade weaker, but there remains a possibility that the 2001 Census is still missing significant numbers of residents.

A third of the discrepancy was put down to errors in the estimates of migration during the 1980s and therefore in the 1991 census. While plausible, it was calculated by drawing a smooth line between age-specific sex ratios of 1981 and the 2001 estimates published in October 2002. There is no evidence to back this particular trend of population in the past two decades. The heavy judgements made in this revised 1991 population were recognised when they were not revised again by drawing new smooth lines after the 2001 population was itself revised upwards in September 2003. It is pertinent that had this component been re-revised, it would be downwards by about 100,000; there would be a further 100,000 unattributed discrepancy to explain in the population estimates of the 1990s.

The 'errors' found in monitoring international migration in the 1990s are a mixture of weaknesses in the method that are improved by better use of available data, and assumptions. For the new category of 'migration switchers' the flow out of the UK is assumed to be five times that of the flow to the UK. This assumption produces a net impact of about 116,000 emigrants. It is based on no data and flawed logic, the only justification being the circular assertion that if the 2001 Census is correct then there must be an asymmetry of migration that has not been captured in the estimates up to now.

Finally, there remains the 'unattributed' portion of the difference between census-based and rolled forward population estimates. ONS state that "It is thought that a large part of this remaining amount may be due to changing residence status"[18], referring to the unknown number of UK residents who have taken up dual residence with another country, and the unknown impact of such people on the census and the population estimates. This unattributed component, together with each and every part of the previous components which rely on significant assumptions, emphasises uncertainty in the mid-2001 population estimates.

The addition in September 2002 of 193,000 people to the One Number Census is small relative to the total population estimate, just 0.4%. However, this amount is well outside the 95% confidence interval given for the total population of England and Wales, and significantly affects the use and interpretation of population estimates.

- It transforms the increase in mortality for young men during the 1990s into a decrease.

Uncertainty in the national population estimates affects their use more generally.

- It affects the interpretation of employment and unemployment statistics vital to the economic strategy of national and local agencies
- The lack of knowledge about the timing of changes in population during the 1990s, likewise makes difficult both interpretation of history and projection forward of trends.

There is nothing particularly different about the UK. Population is difficult to count in most countries of the world, and is unlikely to get easier in the UK. International migration statistics are extremely unreliable across the world. However, the conclusions at this point are the same as after the 1991 Census. First, there is a need for stability: methods that yield one population estimate that is not so far from the rolled-forward population estimates. Second, there is a need for this number to be accurate.

*Sub-national population estimates*

Sub-national population estimates are perhaps more important than national estimates. They determine where investment will be made and where it will not. Just how important is their accuracy is ultimately a political question. The leeway for inaccuracy may be less when there is little ability to raise local income for services, and when the size of the cake shared by areas is felt not to keep pace with needs.

The Local Government Association's report earlier this year identified concerns with:

- the limited information available about quality assurance of Census results,
- the failure of administrative comparisons to trigger changes to the census-based population estimates, and
- the unconvincing geography of undercount.

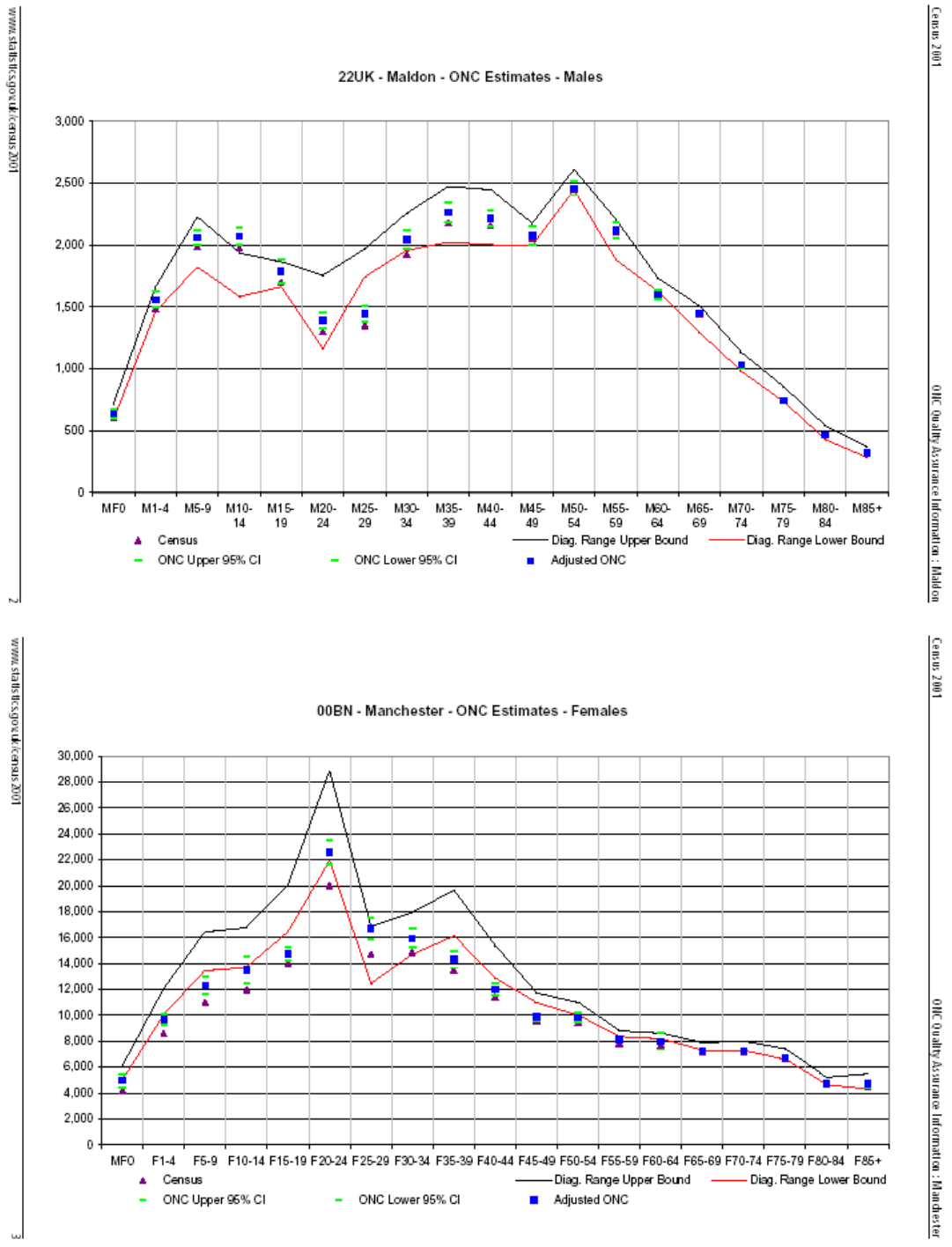
The Office for National Statistics knows that those who understand and use its data are the first line of defence from those who criticise good statistics from the standpoint of ignorance. Those census users are happy to be in partnership with ONS to maintain a vigorous and useful statistical system. But they do need information to play that supportive role. In the future, user representatives could be more insistent to agree outputs as part of the agreed methodology, so that the resources are in place to produce and release quality assurance information.

*Diagnostic ranges from administrative records*

ONS used information about specific groups (armed forces, students and prisoners), and amended the census counts where there were major differences – their website explains some of the details.

A variety of independent population estimates and administrative records including birth, child benefit and pension counts were then used to construct "a range of plausible values" for each local authority area. These diagnostic ranges were wider than the range of the independent indicators themselves. They were intended to be so wide that they would diagnose where the census-based estimate was so far from expected that a failure may have occurred in census procedures.

Diagnostic ranges and One Number Census results, Males in Maldon (Essex) and Females in Manchester)




Source: ONS website. http://www.statistics.gov.uk/census2001/quality_indicators.asp

The quality assurance meetings at ONS after the Census had charts like those above that are now on the ONS website. In Maldon in Essex, the ONC figure – the black square – is just above the census enumeration – the black triangle – and often indistinguishable from it, and normally lies happily within the diagnostic range. Two age groups for males, 10-14 and 25-29, lie outside the range and would be the subject of QA discussion[19]. In Manchester, the One Number Census for most age groups, male and female, lies outside the diagnostic range – the chart shows females. ONS discussed places like Manchester in great detail. There are 14,000 of these comparisons, 37 age-sex groups for each local authority.

In over 20% of these 14,000 comparisons, the final One Number Census population remains outside the diagnostic range. In none of these cases did the failed diagnostic range lead to borrowing strength from another area. It seems clear that the administrative records were not good enough to do the job asked of them. The quality assurance of the census results is the weaker for not providing a check for possible failures of the procedures.

The reports from both the Local Government Association and the Statistics Commission point out that the 95% confidence intervals provided by the ONC design imply that for 5% or 21 local authorities in the UK, their true populations lie beyond them. These are precisely the extreme cases that quality assurance using administrative records was intended to identify and could not.

*Sub-national distribution of census undercount*

Turning to the distribution of undercount as estimated from the One Number Census, the table shows that it is highest where one would expect – in London and the cities. The other two columns show the ratio of male undercount to female undercount among young adults. Young adults aged 20-34 make up about two thirds of all residents missed by the census. The first column, computed from the ONC statistics, shows that in those places with the highest undercount the missed young adults

| | **Undercount rate, all persons** | **Composition of undercount: Male 20-34 rate/ Female 20-34 rate** | |
|---|---|---|---|
| ***Type of District:*** | **Estimated September 2003** | **One Number Census** | **Estimated September 2003** |
| **Inner London** | 24% | 1.11 | 1.42 |
| **Outer London** | 12% | 1.15 | 1.58 |
| **Principal cities** | 9% | 1.30 | 1.61 |
| **Large cities** | 5% | 1.30 | 1.65 |
| **Small cities** | 7% | 1.36 | 1.86 |
| **Resort, port and retirement** | 7% | 1.25 | 1.59 |
| **Other metropolitan Districts** | 4% | 1.25 | 1.33 |
| **New towns** | 5% | 1.35 | 1.56 |
| **Industrial areas** | 5% | 1.30 | 1.30 |
| **Urban and mixed urban-rural** | 4% | 1.35 | 1.41 |
| **Remoter, mainly rural** | 4% | 1.42 | 1.45 |
| **England and Wales** | 6% | 1.22 | 1.51 |

are less male dominated. It could indicate a bias in the ONC estimation of undercount such that there were too few young men[20]. The final column shows that the estimates of undercount embodied in the September 2003 revisions to the ONC completely remove that pattern. The revisions were small nationally, but restricted the allocation of young men to one fifth of local authority areas, those which had percentages above the average of lone parent families, 'other non-family' household structures, or residents born outside the UK[21]. It seems these were the very areas that had a low male/female undercount ratio in the ONC. The result is a more plausible pattern of undercount.

Dave King has pointed out that a handful of Districts account for most of the reduction. Forest Heath, Cambridge and Southend in the East of England. Leicester, Nottingham and Derby in the East Midlands. And so on[22]. These are Districts with sub-populations that continue to be hard to monitor and hard to enumerate in censuses. Avoiding undercount of ordinary populations is important, and measuring the student, armed forces, and other transient populations is also important. One without the other is not enough.

I have already mentioned the work by ONS with Manchester and Westminster Councils to establish the completeness of the census address lists, which may result in further adjustment to the population estimates in those and other areas.

The sub-national distribution of the additional estimates of undercount (230,000 + 193,000) is crude, plausible but not determined by evidence. It detracts somewhat from the estimation based on the Census and its coverage survey which gave detailed local estimates of what is the major part of census undercount.

Are the sub-national census output and population estimates fit for their purposes? The uncertainty attached to them derives both from the sample-based estimate of undercount from the Census and its Coverage Survey, and from the additional adjustments necessary because of the dependence between the Census and its Coverage Survey. These additional adjustments added up to 20,000 residents to areas in a formulaic way, and did not make up for localised failures of fieldwork. It is to be expected that there were some failures of fieldwork that have not been reflected in the adjustments to date. These three factors – sampling error, distribution of national adjustments, and un-discovered fieldwork failures – mean that some authority populations are likely to be significantly in error. There is no way of knowing which they are, nor of closely quantifying the uncertainty, but it is reasonable to expect some errors of up to 10,000. These are likely to be in areas where the estimated census undercount was particularly high, and in areas where low census undercount was estimated contrary to expectations.

Such errors certainly have an impact on census uses, though one would normally not be aware of them because they have not been measured.

- Population projections, on which housing and health resources directly depend, are affected by the uncertainty in estimates of migration which are derived from change in the population estimates.
- Population estimates, on which local authority grant from government depend.

- More generally, areas of relatively high undercount can place little faith in their statistics of commuting and migration with other areas.

ONS has decided – with neither consultation nor research justification, for the last time one hopes – to adjust their population estimates for this decade by an amount reflecting one tenth of the unattributed error in the last decade's estimates, local authority by local authority. This is a logical correction for 'drift' in the estimates, but only if the error has been accurately measured, and the method of estimation is the same in both decades. Neither of these conditions has been met. Measurement of the error in the last decade's estimates depends on an accurate population estimate for 1991, which does not exist, as well as for 2001.

**Conclusions**

In 2001, there was unnecessarily widespread undercount. The ONC plans coped with this, and as planned reduced its impact in Census output. The strategic aim of full-population coverage in census output has been established and must be maintained.

However, quality assurance has failed to distinguish sufficiently between migration and undercount. The census results suggest major emigration over the past two decades, but this cannot be corroborated from migration data themselves.

Sub-nationally, in too many cases, administrative indicators of the population deviate from the sub-national census-based populations; but those other indicators are themselves too weak to substitute for the census. We have to go with the Census, and it is excellent for most purposes, but that is no consolation for the important decisions that as in 1991 are dependent on a census base that is approximate to an extent that seriously affects resource distribution and the monitoring of social trends.

1. The small cell adjustment for aggregate data should be reviewed and its impact on census fitness for purpose measured and weighed against measured risks of disclosure of personal information in aggregate tabulated data.

2. Whatever the correctness of the total population, we need to get used to the Census as an estimate of the truth. Census agencies should produce or commission quantified advice on the likely size of errors attached to the census estimates. This will help users and help plan future censuses.

3. A 'third source' of independent population estimates is essential to validate and if necessary calibrate census-based population estimates, at least for the total population of each country. It is the lack of such a reliable third source that has sunk population statistics into debate during the last two decades.

4. At the same time, a high-response census across the country is a prerequisite to trustworthy local statistics and sub-national comparisons. Improved management of fieldwork can make real differences to the enumeration. The postal collection of forms needs complete reconsideration. If better enumeration depends on a reduced form or a different method of collection, then these should be considered.

5. The census operation must deliver data and information supporting it to a pre-arranged timetable that meets users' needs. More generally, a collaborative and partnership approach in census preparation, collection and dissemination can reap dividends in accuracy and utility.

6. In the near future, measurement of international migration needs setting on a new footing, not reliant on major assumptions.

7. Current population methodology should reject any reliance on the revised national 1991 population estimates and trends since 1991.

8. We should plan to research *why* people are missed, whether they choose to be missed or procedures are not good enough. This knowledge is key to improving the population estimates.

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[1] Liz Spencer, Jane Ritchie, Jane Lewis and Lucy Dillon (2003) Quality in Qualitative Evaluation: A framework for assessing research evidence. London: Government Chief Social Researcher's Office, Occasional Papers Series No.2

[2] The paper does not review other matters such as the success or omission of particular questions.

[3] Maximising coverage in the 2001 Census, David Thorogood and Wayne Codd, Paper to the One Number Census Steering Committee ONS(ONC)(SC))97/09, p2. http://www.statistics.gov.uk/census2001/pdfs/sc9709.pdf

[4] House of Commons Treasury Committee (2002) The 2001 Census in England and Wales. Report, together with proceedings of the committee, minutes of evidence and appendices. HC 310. London: The Stationery Office Limited. Evidence.

[5] House of Commons Treasury Committee (2002) op cit. Evidence p22.

[6] Simpson (2001) Census fieldwork – the bedrock for a decade of social analysis. Manchester: CCSR occasional paper 22, University of Manchester.

[7] The rates take into account the revised population estimates for 1991 published in February 2003, and the revised population estimates for 2001 published in September 2003. The 1991 census enumeration, population estimate and undercount data has been converted from 1991 wards to 2001 District boundaries. For both 1991 and 2001, the non-response rate is computed for census day as the number of residents who were not on returned census forms divided by the total number of residents. The detailed calculations are available on request.

[8] ONS Data quality evaluation report, http://www.statistics.gov.uk/census2001/dataqualityevrep.asp

[9] ONS edit and imputation report, http://www.statistics.gov.uk/census2001/proj_eai.asp

[10] In 1981 and 1991, a random addition of 1 or -1 to around a fifth of cells was intended to prevent the sure identification of individuals. Users argued strongly and understood that they had won the case for not using random adjustments in 2001, for having consistent tables, as the compromise between disclosure control measures and fitness for purpose. The decision of the National Statistician in Autumn 2001 to eliminate all 1s and 2s overturned this understanding. Every user forum condemned the decision and demanded consultation and papers justifying the measure. The Treasury Committee of MPs recommended reconsideration and after consultation over alternative proposals, the measure described in the text was adopted, described as 'Small cell adjustment' in ONS report AG(02)03 '2001 Census disclosure control in England and Wales, alternative options'.

[11] The calculation follows from relationships within the published data themselves and from ONS assurance that the adjustment adds no bias on average to census output (the assurance is given in '2001 Census disclosure control in England and Wales, alternative options', AG(02)03, 2003. London, ONS, p33.

[12] Oliver Duke Williams (2003) The 2001 Census Origin-Destination statistics, unpublished paper to the British Society for Population studies annual conference, Bristol, 10-12 September 2003.

[13] Office for National Statistics (2003). 2001 Census disclosure control in England and Wales, alternative options. AG(02)03. London, ONS, p36.

[14] Simpson (2002) Contribution to discussion of options on disclosure control. http://www.ccsr.ac.uk/ImpactofRoundin.pdf

[15] Cole, K. (1993). The 1991 Local Base and Small Area Statistics. The 1991 Census User's Guide. A. Dale and C. Marsh. London, HMSO: 201-247.

[16] The 2001 One Number Census and its quality assurance, a review. LGA research briefing 6.03, prepared by Ludi Simpson, John Hobcraft, and Dave King, September 2003. London: Local Government Association. The 2001 Census in Westminster: interim report, October 2003. London: Statistics Commission.

[17] http://www.statstics.gov.uk/about/methodology_by_theme/revisions_to_population_estimates/introduction.asp

[18] http://www.statstics.gov.uk/about/methodology_by_theme/revisions_to_population_estimates/implications.asp

[19] These QA meetings were detailed and frequent, weekly in the first half of 2002 and sometimes twice-weekly.

[20] This pattern was pointed out by Philip Redfern talking on validation of the Census at the Royal Statistical Society general meeting, July 9th 2003. This will be published in 2004 by the Journal of the Royal Statistical Society (series A), with discussion.

[21] http://www.statistics.gov.uk/about/methodology_by_theme/revisions_to_population_estimates/downloads/Methodology_for_revision_to_mid-2001.pdf

[22] LGA research briefing 6.03, op cit, and BURISA magazine