

Errors of Non-observation: Dwelling Non-response and Coverage Error in Traditional Censuses

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Abstract

Every census, when concluded, has some residual level of non-response and coverage error. This paper considers the case of a traditional census where enumeration at a usual place of residence takes place via direct contact with respondents using possibly multiple collection modes. The sources and patterns of these errors as well as strategies to minimize their occurrence and impact are both discussed. Commonality of causes and interactions between the errors are briefly considered. Means of measuring and adjusting for these errors are also noted. Although reference will be made to other censuses, the Canadian census will primarily be used to illustrate the discussion

Keywords: dwelling classification error, Reverse Record Check, post-enumeration survey, total survey error

1. Introduction

To quote the appealing title of a book from the U.S.A. National Research Council (2006) a key objective of any census of population is to enumerate each in-scope person "Once, Only Once and in the Right Place". Most modern censuses are of very high quality, yet none is fully successful in meeting this objective; there is always a small percentage of non-observation of persons. Of interest for this paper are dwelling non-response and undercoverage error. They are similar; persons who should be enumerated are not. And there are differences. For example, in Canada imputations are made to account for dwelling non-response and the associated persons can be viewed as "enumerated by imputation". On the other hand, no adjustments for coverage error are made to the census data and counts. (However, the population estimates program does incorporate adjustments for net undercoverage error.) The 2011 Canadian Census will be used to illustrate these topics. Item non-response and overcoverage are not considered in this paper.

Section 2 provides an outline of the 2011 Canadian Census data collection methodology, highlighting features aimed at minimizing non-response and undercoverage. In the context of this methodology, section 3 reviews sources of these two errors. Sections 4 and 5 give overviews of the methods used to measure and adjust for them. Section 6 gives results concerning non-response for the 2011 Census. Finally section 7 provides an analysis and comparison of non-respondents and missed persons using data from the 2006 Census.

2. 2011 Canadian Census Data Collection Methodology

The 2011 Canadian Census used a concurrent mixed mode data collection strategy (Mathieu et al., 2012) implemented with a series of waves of carefully timed contacts designed to maximize response by Internet while minimizing non-response. The primary mode of contact for most dwellings was mail with Statistics Canada's Address Register

(McClellan, 2012) providing the list of addresses. To ensure the best quality coverage of dwellings (minimizing undercoverage with an acceptable level of overcoverage) economically feasible the AR is maintained through feedback from each Census, household surveys using the AR as a frame, an evolving set of administrative sources and field listing. In the months prior to the Census the field listing work was targeted to areas with about 40% of the mailout addresses based upon criteria to identify areas at most risk of dwelling coverage error or geocoding error. About 80% of dwellings were included in the mailout area. For another 18%, the list-leave area, Census enumerators listed dwellings in registers classifying each one as occupied or unoccupied and dropped off of a questionnaire (to be mailed back when completed) at each one. In both cases this was done mainly in the week prior to Census day, May 10, 2011. The remaining 2% of dwellings, primarily in remote areas, were visited by an interviewer.

As usual to help ensure correct coverage of persons, instructions were provided on the paper questionnaire indicating who to include and who to exclude. On the internet questionnaire the same information was available via a help function. In addition to the roster of usual residents, respondents were asked to provide information regarding persons who they were unsure should be included or not. This information was clerically reviewed, with follow-up as required, to determine any necessary roster changes.

A communications campaign, including the messaging on envelopes and in the letters used in contacting dwellings, was carefully tested and designed to support minimizing non-response in this wave strategy. For example, letter messages went from “Census is here; complete it within 10 days” at wave 1 to “Completion of the Census questionnaire is a legal obligation for every household in Canada” at wave 2 to “Completion ... **Important note: If you refuse ... may be documented and referred to the Public Prosecution Service ...**” at wave 3.

For wave 1, three quarters of those in mailout areas received an invitation letter, providing a unique access code linked to the address and encouraging response via Internet; instructions were also provided on how to obtain a paper questionnaire (to be mailed back when completed) if so desired. These areas had been identified as those most likely to yield high rates of response by Internet (Côté et al., 2011). The remainder of the mailout group as well as those in the list-leave area received a questionnaire package providing an Internet access code and a paper questionnaire.

In both mailout and list-leave areas wave 2 started on Census day. In the former reminder letters were mailed to all non-responding dwellings while in the latter thank-you/reminder cards were delivered to all dwellings as unaddressed mail.

Wave 3 was initiated 8 days later for non-responding dwellings that had received the wave 1 letter. They were now sent a questionnaire package. Wave 3 took place a few days later for non-responding dwellings that had received a wave 1 questionnaire by mail; they now received a voice broadcast telephone message if they had a telephone number on the frame. There was no wave 3 event for dwellings in the list-leave area.

For 2011 a new operation, Dwelling Occupancy Verification (DOV), was undertaken shortly after Census day and prior to the start of non-response follow-up (NRFU) in mailout areas. The objective was to identify non-responding dwellings that were unoccupied on Census day, classify them as such and remove them from the workload for NRFU. Each DOV enumerator was provided with an assignment of dwellings to be

classified as occupied or unoccupied by enquiring with an occupant or other knowledgeable person. There was no DOV questionnaire, nor was the Census questionnaire to be completed by the DOV enumerator.

In total about 18% of all dwellings in the mailout area were included: those having the highest probability of being unoccupied. All dwellings in buildings having 50 or more apartments were included. Dwellings with no telephone number on the Address Register were also included from two groups: addresses added to the Address Register during the year prior to Census day (mainly new construction); and addresses on blocks which a regression model predicted would have high unoccupied rates. Previous analyses had indicated that about 98% of dwellings with a telephone number on the AR were occupied and so only addresses without telephone numbers were retained for DOV.

In mailout areas wave 4, consisting of regular non-response follow-up with field interviewers, was initiated 22 days after Census day. In the case of the list-leave areas, this work was started 10 days after Census day. NRFU was undertaken for all dwellings not classified as unoccupied with the objective of obtaining a completed questionnaire from each one. For dwellings in the mailout area but not in the DOV the first step was for the enumerator to identify those which were unoccupied on Census day. In both areas, NRFU then continued for only the dwellings classified occupied until August 5th, 2011.

With the availability of a near real-time collection management information system, it was possible to implement a simple dynamic resource allocation strategy during NRFU with the objective of maximizing the overall response rate while concurrently obtaining response rates as uniform as possible at local levels. In a first stage over the first several weeks of NRFU, response rates were monitored both for each collection unit (CU) of about 300 dwellings, and at a slightly higher geographic level. If the response rate of a CU reached 98% or if it reached 96% with the rate for the larger geographic unit at 98% or more, NRFU for the CU was stopped and the resources reallocated. In the last weeks of NRFU a second stage was implemented to reduce the volume of work in areas where progress had slowed considerably or where enumerator staffing levels had fallen too low and could not be replenished. When the impact on response rates would be acceptably low, work was stopped in such areas so that enumerators could concentrate their efforts in areas with larger amounts of work remaining and where progress still seemed feasible.

3. Sources of Non-observation

In executing a data collection methodology such that just described both coverage errors and non-response will occur. The sources and causes are many, some potentially leading to only one of these error types and a few having the potential to cause either. This section provides a short discussion of these error sources and their management.

Missed dwellings and hence missed persons:

Data collection for a traditional census starts with construction of a dwelling frame. Non-observation errors arising from errors at this stage are strictly coverage errors and not non-response.

In the mailout area the quality of coverage critically depends first on the quality of the Address Register. It has three major sources of update: dwellings listed in the previous census, updates from administrative sources during the intercensal period and updates

from surveys and field listing activity. While the previous census will have missed some dwellings, the use of administrative data provides an opportunity to correct those errors as well as to make updates for new construction and other changes to the dwelling stock. No single administrative source is perfect and the use of multiple sources helps mitigate the deficiencies of each at the risk of increasing the overcoverage of dwellings. A balance must thus be struck so that undercoverage is sufficiently minimized without excessively increasing overcoverage. Last, after having identified those areas of the country where the AR was judged to be of sufficiently high quality to serve as the dwelling frame for the Census mailout area, field verification of the dwelling lists from the AR was done. This verification was done in the 40% of CUs in the mailout area judged to be at most risk of dwelling coverage error (McClean, 2012) and took place over the two years immediately prior to Census day. After completion of this work, it was estimated that dwelling undercoverage in the mailout area was 0.6% to 1.3% higher than it would have been with 100% verification. An important mitigation during Census data collection was a coverage improvement process where additional listing work was undertaken in areas where there was clustering of calls from persons saying they had not received a questionnaire; about 0.54% of dwellings in the mailout area were added in by this process.

In the non-mailout areas the traditional approach of having census enumerators list dwellings in a register was used. As is well known, these enumerators commit coverage errors at a small rate that is a function of their training, their skill level and the intrinsic challenge of dwelling listing. For example, some dwellings such as basement apartments can be very difficult to identify. Another example is that sometimes dwellings are erroneously omitted when thought to belong to a neighbouring work assignment.

Missed persons in enumerated dwellings:

The second source of undercoverage is persons omitted from the questionnaires of responding dwellings. One of the first steps in completing a census questionnaire is to provide the roster of usual residents on Census day. Why are some persons omitted?

To properly complete this roster, reference to usual place of residence rules is needed and paper census questionnaires normally provide simplified instructions on who to include and exclude. Internet questionnaires provide basic information in the context of the rostering questions with more detailed information available via a help function. In both cases further help is typically available by phoning a help operator. It seems likely that many households, particularly nuclear families, can provide a correct roster without reading the residence rules. Even for these though it is not entirely easy; why are infants missed at higher rates than older children in so many censuses?

But for many others, reading and understanding these rules is necessary; failure to do so can lead to omissions (and sometimes erroneous inclusions). What are the barriers? The hasty respondent who just wants to “fill in the white space” may easily omit persons with less clear attachment to the dwelling such as lodgers. For the same reason, young adults in transition between living with parents and living independently can easily be omitted or enumerated twice. Even with reading the residence rules errors can still occur if the parents and the young adult do not have the same view as to the young adult’s usual place of residence. For these same reasons persons whose usual place of residence is uncertain are more easily missed. Persons with literacy or other difficulty in the language of the questionnaire (even though help is available in numerous languages) may also be subject to higher rates of undercoverage error.

If responding on the paper questionnaire dwellings with more than 6 usual residents required a second questionnaire, for which a special request had to be made. Those in some such dwellings may choose not to request the additional questionnaire, resulting in a small amount of additional undercoverage.

Even when self responding, the more time elapses before response the more risk there is of error in recalling and correctly reporting who the usual residents were on Census day, potentially resulting in both undercoverage and overcoverage.

A first step in processing of census responses is editing for completeness and coherence. Invalid persons resulting from respondent or data capture error are deleted, as well as duplicate responses. The rate of error in this process is very low but it is possible that valid persons are deleted, resulting in a very small contribution to undercoverage.

Non-response:

Non-response follow-up by field enumerators is typically the last phase of census data collection. At the end of this operation there always remains a small percentage of non-response. First, why do some in-scope households not self-respond in a reasonably timely way? Then, what are the factors that lead to some of these remaining as non-respondents at the end of NRFU operations? The topic of non-response in household surveys has been extensively studied; Groves and Couper (1998) is an especially useful reference.

Long before NRFU even got started it was essential that every questionnaire or invitation letter be delivered or dropped off at the correct address. Unique identifiers and internet access codes linked to the address were used to facilitate controlling and tracking of data collection operations. Although rare, any misdelivery of mailout packages or incorrect dropoff of questionnaires had the potential to lead to non-response. In such situations, NRFU for dwellings which received the wrong questionnaire and did not self-respond would occur at the address where the questionnaire should have gone.

Critically important in minimizing non-response as well as persons missed in responses completed during NRFU is the hiring of an adequate quantity (including replacements) of capable enumerators trained in the skills needed to solicit cooperation and response from sometimes reluctant household members.

The responsive design strategy of stopping NRFU work in one area to reallocate resources to another where NRFU progress is more essential can obviously affect non-response. The non-response rate in the former area will be higher than it might otherwise have been and lower in the latter with the effect of more equitable data quality across the areas. The net effect will typically be an overall reduced non-response rate, but in some cases may be the opposite even though the situation is improved from the perspective of data quality for small domains.

As it concerns actual data collection activities in the Canadian census described above, a first source of non-response is errors in the classification of dwellings. Since dwellings that have been classified as unoccupied receive no further NRFU effort, errors in classifying occupied dwellings as unoccupied result directly in non-response. The issue here is the training and skill of the enumerators at this often difficult determination when

they have other competing priorities. The risk of error is increased further if long lapses of time occur between Census day and a first NRFU visit.

The choice to respond, and the completeness of that response, whether as a self responder or as a result of NRFU effort can be affected by many factors including: attitudes on the part of residents as it concerns government, surveys and the census; salience of the census as an important activity and in general the degree of civic engagement; do-it-now versus procrastination attitudes; literacy in an official language; data collection strategies; enumerator characteristics and skills; quality of communications messages associated with the census; questionnaire design features; usability of Internet questionnaire and many others.

Failure to even make contact with a household member will result in non-response. In some cases this happens because all usual residents are absent throughout the entire data collection period. More common though is the challenge of small households, especially one person, where residents are frequently not at home and so very difficult to contact. A growing challenge in many countries is gated communities and apartment buildings where even obtaining access to attempt contact can be difficult.

Even once contact is made in NRFU, some of the root causes noted above in the initial choice to respond or not can have an impact. Persons who see the census as not interesting or not important may refuse to respond despite repeat visits from more senior enumerators. Even when care has been taken to hire enumerators with knowledge of languages matching those of local populations, higher rates of non-observation may occur from groups having difficulty in either official language. Again attitudinal factors such as any lack of trust in government, the statistical office, or in assurances of confidentiality and privacy can lead to some non-response when enumerators are unable to reassure and convince residents to respond.

As time goes by during NRFU a small but increasing proportion of households as of Census day will have moved, with the impact that any contact is with a household no member of which was a usual resident at the address in question on census day. The likely outcome is either a non-response or the reporting of a household which did not live there on Census day and who may well have been already enumerated elsewhere.

4. Measuring and Adjusting for Non-response

At the completion of NRFU there is always a small percentage of dwellings with no response. At this point each outstanding dwelling has been classified as either unoccupied, meaning no usual residents on Census day, or non-response, meaning an occupied dwelling that has not completed a questionnaire. This dwelling classification is evaluated for its accuracy, and then adjustments are made to the Census database to account for estimated rates of dwelling classification error.

Dwelling classification errors impact non-response follow-up operations in two ways. First, an unoccupied dwelling misclassified as occupied, will have required expenditure of resources that could more usefully have been directed towards genuinely occupied dwellings. Second, an occupied dwelling misclassified as unoccupied, is not included for NRFU and directly contributes to non-response. The Census uses a coverage survey – the Dwelling Classification Survey (DCS) – to estimate the frequency of these two types of

misclassification error and to adjust the Census database, imputing whole households into appropriate proportions of the dwellings with no census response.

The objective of the DCS is to provide estimates of the number of occupied dwellings, with the household size distribution, in both the unoccupied and non-response dwelling universes. These estimates are used to derive adjustments to be incorporated on the Census database. The DCS target population is dwellings that did not return a Census questionnaire. The DCS takes a sample of these dwellings and determines for each the occupancy status on Census Day and, if occupied, the number of usual residents. Dick (2008) provides a detailed description of the DCS and the imputation procedure as implemented for the 2006 Census. Only rather minor changes were implemented for 2011; the following provides an overview.

The survey was taken as a stratified sample of collection units within which all dwellings that did not return a Census questionnaire were selected for interviewing. Initially, the frame of first stage units was the list of all 50,000 CUs used for the 2011 Census. Strata consisted of Vancouver, Toronto and Montreal Census Metropolitan Areas, the aggregate of the remaining urban areas in each province and the residual rural part of each province. New in 2011 a procedure for sub-sampling dwellings within a CU was introduced. This allowed the sample of CUs to be expanded from under 1,400 in 2006 to over 1,700 in 2011 without increasing the DCS data collection budget and, in addition, providing a more reliable estimate of the dwelling size distribution. Direct estimation is used for the number of occupied dwellings in both the unoccupied and non-response universes.

Field interviewers were to complete a DCS questionnaire for each dwelling selected in the sample by contacting current occupants, neighbours, landlords, or any other person with some knowledge about the dwelling in order to determine if the dwelling was occupied (with the number of usual residents) on Census Day. An important assumption is that these interviewers, having this sole responsibility, would be able to do a superior job of this classification than the Census enumerators who did the initial classification and who would have had multiple other concurrent duties.

The DCS provides separate domain estimates of the distribution of dwellings by household size (including zero) – for each universe in each stratum. Using this information, adjustments and imputations are done on the Census database via a process called Whole Household Imputation (WHI). Within each stratum the following steps are undertaken for each universe.

The dwellings in the DCS universes are randomly assigned a household size ranging from zero to six in such a fashion that the household size distribution for that universe in the stratum as estimated by the DCS is reproduced. In the case where a dwelling classified as non-response is assigned a household size of zero, it is reclassified as unoccupied and similarly when a dwelling classified as unoccupied is assigned a household size of more than zero it is reclassified as non-response occupied. Then for each dwelling assigned a non-zero household size, a whole household was imputed using the data from a randomly selected donor household of the appropriate size selected from the same block or same CU if no suitable donor was available from the block.

The critical assumption in this imputation model is that controlling for household size and spatial proximity in this manner, non-respondents are similar to respondents.

The success of Census data collection operations is evaluated, in part, by the data collection response rate – (the number of responding dwellings) / (the number of dwellings classified as occupied during Census data collection). Completion of the DCS and the WHI provides additional evaluative information via estimates of:

- the number and rate of occupied dwellings misclassified as unoccupied,
- the number and rate of unoccupied dwellings misclassified as occupied,
- the number of persons living in dwellings on the Census dwelling list but from which no response was received and
- a final response rate equal to (the number of responding dwellings) / (the estimated number of occupied dwellings on the Census list).

5. Measuring Undercoverage

While many countries such as England and Wales (Brown, Abbott and Smith, 2011) and the USA (Whitford, 2008) use a post-enumeration survey, Canada uses the Reverse Record Check (RRC) methodology (Dolson, 2010 and Statistics Canada, 2010) for estimating undercoverage. Its use in the 2011 Census is briefly described in this section.

The RRC estimates the number of in-scope persons not enumerated (not observed) and by subtracting out the number of DCS based imputations, the estimate of persons missed in the Census is derived. Final estimates will be available in September 2013. The objective is to produce good quality estimates of undercoverage for Canada, each province and territory and important subgroups.

The 2011 RRC has used a set of five frames for the provinces: persons enumerated in 2006, persons classified as not enumerated in the 2006 Census by the 2006 RRC, lists of intercensal immigrants and non-permanent residents (NPR) provided by Citizenship and Immigration Canada and lists of intercensal births coming from provincial vital statistics registries. Frames for the three territories were extracted from territorial health care files.

The sample design for the provinces is a stratified SRS of persons. The 2006 Census frame was stratified by province, sex, marital status and age group (differing age groupings by marital status). Other frames were stratified by province only. The sample of about 70,000 was allocated to provinces primarily for equal precision of estimates of the missed rate. Within provinces, Théberge's (2006) procedure for optimal allocation with smoothing of design parameters was used. The immigrant and NPR frames can overlap with each other as well as with the missed and 2006 Census frames. Using record linkage, steps are taken to remove this frame overlap. For the first time, weights for the sample from the previous (i.e. 2006) Census frame will be adjusted to account for overcoverage in the frame. A potential relative bias of about 1.6% is thus removed.

Following sampling for the provinces, frame data for each sampled person (SP) and their household members were matched to income tax data and other administrative sources such as driver's license files and an electronic telephone directory (Infodirect) to obtain more recent addresses (and telephone numbers) to assist in determining if the SP was enumerated and, if necessary, for use in RRC interviewing.

Once the final Census database was available in October 2011, RRC processing was started. For the territories, the first step was an exact match by name, sex, and date of birth of the entire frame of about 115,000 persons to the 2011 Census enumerations.

After clerical verification, confirmed matches were classified as enumerated. A stratified SRS of about 2,000 of the non-matches was selected for interviewing and further processing. More generally, the objective of RRC processing is to: classify each SP as enumerated (and thus assumed in scope), in scope and not enumerated, out of scope (e.g. dead or emigrated) or not traced (not classifiable as in or out of scope); determine the usual place of residence for persons classified not enumerated; and derive other variables for non-response adjustment.

This is a large record linkage operation with both automated and computer assisted clerical steps in which the Census database is searched for each person in the RRC sample. For each SP the Census database is searched at potentially several addresses:

- addresses found via record linkage using name, date of birth and sex of the SP,
- addresses found via record linkage using telephone numbers available from the frame or administrative sources,
- addresses with household composition similar to the SP's on the RRC frame
- the SP's address from the frame and
- addresses from the frame or administrative sources.

As well, the sample was matched to death registrations to identify SPs who had deceased prior to Census day.

By this process more than 80% of the SPs were found and classified as enumerated or out of scope (deceased). SPs not found enumerated or deceased were sent for tracing and interviewing. A second phase of processing then takes place for SPs who are interviewed where the Census database is again searched using the new information. Each SP is assigned a final classification. For 2011 this work is still in its final stages but in 2006, about 95.5% of SPs could be classified as enumerated, not enumerated or out of scope and so were respondents for the purposes of estimation.

RRC data collection was started in January 2012 using primarily CATI. All the case information for each SP not classified enumerated in the first phase of processing, including the various addresses noted above, is forwarded to a regional office where further tracing using local resources is done if necessary. An additional subsample of about 7,500 SPs already classified as enumerated was also interviewed to facilitate estimation of a parameter critical for the non-response adjustment methodology. The RRC interview collects the Census day roster, demographic data, the Census day address and other addresses where the SP might have been enumerated as well as information needed to determine if the SP is in scope or not.

In the RRC, the large majority of non-respondents are either not enumerated or out of scope. Not enumerated SPs whose usual place of residence is at an address known prior to any interview related activity are easier to locate and interview than others who require tracing effort. Because of factors such as these, a great deal of care must be taken to ensure estimation remains as unbiased as possible. Consequently, RRC processing must also classify each SP as to:

- whether the SP was classified with or without using data from the RRC interview
- whether or not the SP's usual place of residence was available only from interview data.

The non-response adjustment procedure developed by Théberge (2008) incorporates this information and will again be used with direct estimation, treating the design as a two phase sample.

By these procedures the RRC produces estimated totals of persons not enumerated, incorporating both persons in non-responding dwellings and persons who were missed. To arrive at estimates of missed persons only, i.e. undercoverage, estimates of non-respondents must be subtracted out. This latter is the total of persons imputed to the Census database via whole household imputation on the basis of the DCS results.

Following a period of detailed internal review and certification, estimates of coverage error will first be released in March 2013. This is followed by a three month period of intensive collaborative review with representatives of provincial/territorial statistical offices leading to final estimates which will be released in September 2013.

6. Non-response and Whole Household Imputations in 2011

For private dwellings, the Canadian 2011 census had a data collection non-response rate of 2.5%. This is defined as the number of responding dwellings as a percentage of private dwellings classified during census enumeration as occupied. This represents an improvement over the 3.1% obtained in 2006 and is due to improved self response and improved success in NRFU operations despite a one month shorter data collection period.

In sections 6 and 7 as well as Appendix 1 standard errors of estimates are provided in brackets wherever applicable and available.

The DCS provides an estimate of the non-response rate also accounting for non-response arising from occupied dwellings misclassified as unoccupied. This estimated Census non-response rate (or whole household imputation rate) was 2.9% in 2011 resulting in 2.4% of persons in the Census count being imputed. Corresponding figures from 2006 were 3.5% and 2.9%, respectively.

These improvements were facilitated by a few key factors. First, there was a major improvement in the rate of self response from 78.5% in 2006 to 85.1%, reversing a long term trend of slow decline. It appears that the wave strategy to encourage response via Internet while maintaining response rates contributed significantly to actually improving these rates. This improved self response meant a significant reduction in the workload for NRFU which itself was made easier because of an important improvement over 2006 in the ease of hiring and retention of enumerators.

The estimated percentage of dwellings classified unoccupied that were actually occupied improved in 2011 to 13.8% (0.8%) from 17.4% (0.9%) in 2006. Despite a large increase in the number of dwellings classified unoccupied this helped reduce non-response and the amount of person imputation. Meanwhile, the estimated percentage of non-responding dwellings that were indeed occupied remained stable at about 70% (0.9%). So, with the reduced data collection non-response rate, considerably fewer persons were imputed to these dwellings as well.

Another factor in reducing the imputation of persons was that household sizes amongst whole household imputations tended to be smaller in 2011 than in 2006. Households of size 1 accounted for 43.8% of whole household imputations, up from 40.4% in 2006 while the share of households of size 3 or more decreased to 25.5% from 29.2%.

7. Non-observation in 2006

A more complete review of non-observation in the 2011 Census cannot be provided here since estimates for undercoverage will not be available for several months yet. Instead, I provide here a review of non-response and undercoverage in the 2006 Census. While the level of undercoverage may change, it is not expected that patterns by demographic group will change substantially.

In the 2006 Canadian Census the Reverse Record Check estimated the non-observation rate of persons, or Census data collection undercoverage rate, at 7.1% (0.2%). This consisted of an estimated Census undercoverage rate of 4.3% (0.2%) and the person imputation rate of 2.9% (0.1%), accounting for dwelling non-response. In general, non-response rates by demographic group show only minor variation while undercoverage rates vary substantially. In the following I expand on this, considering age, sex, marital status, mother tongue and household size. An important caveat to remember in this is the assumption in the whole household imputation model that controlling for household size non-respondents are similar to respondents within block.

Appendix 1 provides a set of tables presenting information on household and person imputations and person undercoverage. Table 1 shows the distribution of Census enumerations, whole household imputations and person undercoverage by household size. The remaining tables show person imputation rates (from WHI) and undercoverage rates by: household size, mother tongue, age group and sex, and marital status and sex.

Table 1 clearly shows that household sizes of non-responding dwellings, as estimated by the DCS are much smaller than for enumerated dwellings. There is a much higher proportion of households of size 1 and a lower proportion of every larger household size. A similar pattern follows for persons. The size of households in which undercovered persons are found tends to be even slightly smaller than for the persons imputed into non-responding dwellings. Table 2 shows that the estimated non-observation rate of persons varies substantially by household size, from a high of 12.9% to a low of 4.5% for households of size 1 and 4, respectively. Although the patterns are similar, the variation is much greater for undercoverage than for the imputations.

Familiar patterns of estimated undercoverage by age group and sex are seen in Table 3. Rates for males are higher than for females at almost every age group. Very young children are missed more often than older ones. The rates are highest for the 18-34 age group at about 11.5% (0.9%) and 8% (0.7) for males and females, respectively with lower rates for older age groups. An interesting anomaly of negative undercoverage rates is seen at ages 55 or more. In contrast, the imputation rates are lower with very similar rates for males and females and much less variation by age group. Although the difference is small, the highest rates of imputation are seen for ages 55+.

The pattern by marital status and sex shown in table 4 is more complicated. As expected, undercoverage rates are higher for males than females. They are high for never married persons and low for married/common law and widowed, especially females. For males the rate for separated/divorced is similar to the rate for never married while for females it is lower. This difference may be explained in part by the fact that 53% of separated or divorced males were living alone compared to only 40% of females. But this does not translate into a similarly large relative difference in the imputation rate. Imputation rates are more stable with the lowest observed for married or common law persons. It is surprising though to note that the imputation rate for widowed is higher than that for never married when one might have expected the opposite.

Broken down by age group, there are very different patterns of nonobservation by marital status. Generally, the pattern for never married follows that of the aggregate shown in table 3, only with higher rates of non-observation. Separated/divorced patterns are similar to never married although slightly higher for males and somewhat lower for females. Married/common law rates are much lower than never married, at ages greater than 24. But for 15-24 the married/common law rates are greater, although not statistically different, than the never married rates. Unusually low, even negative, undercoverage rates are seen for widowed and married/common law persons over age 64 and for never married females over age 64. The imputation patterns by age group are similar by sex but differ slightly by marital status. For never married, the rate increases slowly by age group from about 2.5% for age 15-19 to 4.0% for age 45+. For married/common law, it is about 3.2% for 15-24 and then decreases to about 2.6% at older age groups. Separated/divorced increases from about 3.1% below age 35 to about 4.2% above age 54.

Table 5 shows rates by mother tongue for two groups: either English or French (Canada's official languages) and neither. (There are other very small groups with multiple mother tongues that are not shown in the table.) The imputation rates are very similar at about 2.7%. On the other hand the undercoverage rate for neither is much higher than that for English or French. Some difficulty is anticipated for persons whose language is neither English nor French and Census has a number of mitigation strategies in place to address this. These results suggest that these steps are much more successful as it concerns minimizing non-response as compared to undercoverage.

Taken as a whole, this information indicates that non-response and undercoverage are similar in that both occur much more frequently in small households. Otherwise, there appear to be substantial differences. Undercoverage is strongly influenced by demographic group while non-response appears less so, provided the modeling assumption holds. High rates of undercoverage are associated with being: male, aged 18-34, never married and under age 45, married and age 15-24, separated/divorced if male, separated/divorced if female under age 35, neither English nor French mother tongue or in a household of size one. Extremely low rates of undercoverage are seen for persons who are over 64 years old and either widowed or married/common law as well as never married females in the same age group. Although the effects are much smaller, higher imputation rates are seen for: households of size one, separated/divorced and widowed persons. As well, slightly higher rates are seen in the oldest age groups. It seems surprising that the rate for never married is not higher than it is. As expected the rate for married/common law is low.

The RRC does an excellent job of estimating the non-observation rate. Deriving good quality estimates of undercoverage also depends upon the quality of the results of the DCS and the Whole Household Imputation process. The DCS does a very good job of estimating the distribution by household size of dwellings with no response in the Census and thus also of the number of persons to be imputed by household size. The quality of the imputations and the extent to which they correctly adjust by demographic group or other characteristic depends, in part, on the validity of the model assumption used for the WHI. Dick (2008) has examined this in detail and concluded that for households of size two or more the imputation process is working well. There is some indication though that for households of size one the WHI appears to impute a few too many older persons, particularly females, and not enough young adults, particularly males. Also, the WHI may be imputing a few too many married persons over age 64, likely mainly in households of size 2. Contrary to what one would expect, the imputation rate for persons over 54 is

higher than for younger age groups and that for widowed is higher than for never married. Further, this is where we observed very low or negative undercoverage rates. The negative rates are not an indicator of overcoverage; that is estimated by an independent process (Dolson, 2010). Rather, this indicates the imputation rate is too high or that the estimate of non-observation is too low (or both!); the first of these seems far more likely.

Why one and two person households? First, it is generally observed that response probabilities are higher for older people than for young adults. If also true in a census then it leads to a problem in households of size 1 where older persons are overrepresented in the WHI donor pool. Because these persons make up a large proportion of both the donor pool (about 25%) and the widowed group (over 60%), the result is a small over-imputation of older persons, particularly widowed women. Further, married persons tend to be good respondents. This has a direct effect in two person households, more than 65% of which are married or common law partners and about two thirds of which are over age 54. By similar reasoning this results in a small over-imputation of older married persons.

This issue will be investigated further using the results of the 2011 coverage studies with a view to potential modifications for the WHI process for the 2016 coverage studies.

8. Concluding Remarks

So what? Even in a high quality well run census such as Canada's a relatively high proportion of persons are not observed, 7.1% (0.2%) in 2006, either due to non-response or undercoverage. The rate is higher for the latter and is differential by demographic group. This clearly indicates where to focus effort to achieve improvement. However, where improvement is most needed, young never married adults, is likely where it is also most difficult. Nonetheless, the very high response via Internet (54%) and the large increase in self response with the wave methodology are encouraging signs. The substantial commitment of resources to reducing non-response is very effective at reducing it across all the demographic groups considered here. It is more successful for large households than small ones. An important factor for non-response is errors in dwelling occupancy classification. Initiatives such as the Dwelling Occupancy Verification process yielded some improvement in 2011. Any further reduction that can be achieved in this error rate will pay off in turn by ensuring full NRFU for a greater proportion of the occupied dwellings and so reducing the non-response rate.

The undercoverage rate is higher than the non-response rate. Which is the more serious error? Clearly undercoverage, given the central role of the census of population in a national statistical system. It is differential by demographic group and so potentially affects inferences made on the basis of census data. Further, it will also affect any future use of the census as a frame for other purposes. At least for non-response, the dwellings are accounted for and, using the DCS results and the WHI procedure, a process can be implemented to impute persons into the non-responding dwellings.

So, in decisions on resource allocation to address non-response and undercoverage, what should be done? An important issue is to improve the rates of both non-response and undercoverage not only for large aggregates but also uniformly across smaller domains as well. A distinction is that undercoverage is a matter of prevention and progress or status cannot be monitored during operations. On the other hand, although there are strategies to prevent or minimize it, non-response reduction is a census operation whose progress can be monitored and where adaptive strategies can be used to address problem areas.

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Appendix 1: 2006 Census Tables

Persons	Households		Persons		
	Enumerated	Non-response	Enumerated	Non-response	Undercovered
1	26.3	40.0	10.5	18.6	20.5
2	33.7	30.6	26.8	28.4	31.8
3	16.0	13.3	19.2	18.5	20.0
4	15.2	9.4	24.2	17.4	12.6
5	5.9	4.4	11.8	10.2	7.0
6+	2.9	2.4	7.6	6.9	8.0
All	100.0	100.0	100.0	100.0	100.0

Persons	Non-response	Undercoverage
1	4.9	8.0
2	3.1	5.1
3	2.8	4.5
4	2.2	2.3
5	2.6	2.6
6+	2.7	4.6

Language	Imputation	Undercoverage
English or French	2.7	3.4 (0.2)
Other only	2.8	8.4 (0.5)

Age Group	Male		Female	
	Imputation	Undercoverage	Imputation	Undercoverage
0-4	2.7	4.2 (1.0)	2.7	3.9 (0.9)
5-14	2.5	3.0 (0.6)	2.5	3.2 (0.7)
15-17	2.5	1.9 (0.9)	2.5	1.2 (0.9)
18-24	2.7	11.6 (1.0)	2.9	8.4 (0.9)
25-34	3.0	11.4 (0.9)	3.0	7.4 (0.7)
35-44	2.8	7.8 (0.8)	2.8	2.9 (0.6)
45-54	2.9	4.1 (0.7)	2.9	1.1 (0.5)
55-64	3.1	2.1 (0.8)	3.2	-0.2 (0.7)
65+	3.2	-0.1 (0.6)	3.3	0.4 (0.6)

Marital Status	Male		Female	
	Imputation	Undercoverage	Imputation	Undercoverage
never married	3.1	10.9 (0.6)	3.1	6.4 (0.6)
married/common law	2.7	2.6 (0.3)	2.7	1.8 (0.3)
separated/divorced	3.9	12.3 (1.5)	3.7	3.6 (1.0)
widowed	3.6	1.4 (1.9)	3.7	0.2 (0.8)