



Information Paper

Measuring Net Undercount in the 2006 Population Census

Australia

2007

I N Q U I R I E S

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Undercount in the 2006
Population Census**

Australia

2007

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AUSTRALIAN BUREAU OF STATISTICS

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ABBREVIATIONS

'000	thousand
ABS	Australian Bureau of Statistics
AEST	Australian Eastern Standard Time
ARA	any responsible adult
ASGC	Australian Standard Geographical Classification
CAI	computer assisted interviewing
CD	Collection District
CLQ	community level questionnaire
CRB	collector record book
DPC	data processing centre
ERP	estimated resident population
FMC	field match code
ICF	Indigenous Community Frame
IR	imputed record
ISC	Interactive Spatial Coder
LFS	Labour Force Survey (Australia)
LR	late return
MSS	Match and Search System
NPD	non-private dwelling
PAPI	pen-and-paper interview
PD	private dwelling
PES	Census of Population and Housing Post-Enumeration Survey
PMC	person match code
PREG	prediction regression
QA	quality assurance
SCR	system-created record
SD	special dwelling
SE	standard error

INTRODUCTION

THE CENSUS OF POPULATION AND HOUSING

The Population Census is a valuable data source for estimating the size and geographic distribution of the Australian population, and for analysing the major demographic, social and economic characteristics of the population, particularly for small geographic regions and other small sub-populations. It provides statistics for decision-making by governments, businesses, community organisations and individuals.

A Census is conducted in Australia every five years by the Australian Bureau of Statistics (ABS). The most recent Census night was Tuesday 8 August 2006. Every person present in Australia on Census night, excluding foreign diplomats and their families, should have been included on a Census form at the place where they stayed.

The Australian Census counts people where they were on Census night. The ABS augments this Census count for net undercount and for Australian residents who were temporarily absent from Australia on Census night, and subtracts the count of overseas visitors temporarily in Australia and enumerated in the Census, to form a basis for the calculation of the Estimated Resident Population (ERP) of Australia on a place of usual residence basis.

Accurate ERPs are required for a wide range of uses, including the allocation to states and territories of seats in the Federal House of Representatives, the distribution of Commonwealth payments to states and territories, and demographic, social and economic studies.

NET UNDERCOUNT

Whenever a Census is undertaken, questions about the completeness and accuracy of the Census count invariably arise. In such a large and complex exercise, it is inevitable that some people will be missed and some will be included more than once (or included when they shouldn't be). Some of the reasons why people may be missed (i.e. undercounted) include:

- they were travelling and were difficult to contact
- they mistakenly thought they were counted elsewhere
- there was insufficient space on the Census form in the household where they were staying and they did not obtain additional forms
- the person completing the form thought that, for example, young babies, the elderly or visitors should not be included
- they did not wish to be included due to concerns about the confidentiality of information or a more general reluctance to participate
- the dwelling they were in was missed because it was difficult to find (e.g. in a remote or non-residential area)
- the dwelling they were in was mistakenly classed as unoccupied.

Some of the reasons why people may be overcounted include:

- they were included on the Census form at the dwelling where they usually live, even though they stayed, and were counted, elsewhere on Census night
- they were overseas on Census night and so should not have been counted at all, but were included on the Census form at the dwelling where they usually live.

INTRODUCTION *continued*

NET UNDERCOUNT *continued*

While every effort is made to eliminate these potential causes of error, some undercount and overcount will invariably occur in the Census. Usually more people are missed than overcounted in Australia, so the Census count of the population would be less than the true count. This difference is called net undercount. In this context, 'Census count' includes person records imputed for dwellings that were non-responding in the Census.

Rates of net undercount can vary significantly for different population groups depending on factors such as sex, age, ethnicity (including Indigenous status) and geographic location. The ABS obtains estimates of net undercount using information collected in a post-enumeration survey conducted immediately following the Census. Estimates of net undercount are used to:

- derive an estimate of the resident population for 30 June of the Census year (2006)
- provide users with an assessment of the completeness of Census counts, allowing them to take this into account when using Census information
- evaluate the effectiveness of Census collection procedures so that improvements can be made for future Censuses.

PURPOSE OF THIS PAPER

The purpose of this paper is to provide information on the development and conduct of the 2006 Census Post Enumeration Survey (PES), and the methodology used to estimate the net undercount in the 2006 Population Census. This is an update of the previous issue of *Information Paper: Measuring Net Undercount in the 2006 Population Census, Australia* (cat. no. 2940.0.55.001) released on 13 July 2006.

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CENSUS POST ENUMERATION SURVEY

OVERVIEW

In Australia, estimates of net undercount in the Census are based on the results of the Census Post Enumeration Survey (PES). The purpose of the PES is to determine how many people were missed in the Census and how many were counted more than once.

The PES is a household survey conducted by specially trained interviewers starting about three weeks after Census night. This is a different collection methodology to the Census, where most forms are self-completed. A major advantage of interviewer administered questionnaires is that people can be provided with assistance if they are uncertain about the meaning of any questions.

For each dwelling selected in the PES, a responsible adult member is interviewed and asked about all persons present or usually resident in the household. In addition to obtaining basic demographic information, questions are asked about each person's usual residence, location on Census night, and any other addresses where they might have been counted in the Census.

Using this address information, the corresponding Census forms are examined at the Census data processing centre to confirm how many times each person in the PES was counted in the Census. The results are then combined and weighted to produce an estimate of net undercount in the Census.

INDEPENDENCE FROM THE CENSUS

The purpose of the PES is to provide an independent check on Census coverage. There are two aspects to this independence: operational independence and population independence. Operational independence requires that Census operations do not influence the PES in any way, and vice versa. ABS controls this very closely as described below. Population independence means that there should be no subgroups of the population where being missed in the Census indicates that a person or dwelling is more likely to be missed by the PES also. This is harder to achieve, but the PES estimation process can adjust for this to some extent by subdividing the population into smaller groups where the assumption of population independence is more likely to be true.

Steps were taken to maintain the operational independence of the 2006 PES from the Census at every stage of the survey, including enumeration, processing and administration. These steps included:

- selecting the PES sample from an independent sample frame
- using separate office staff in the PES and Census where possible
- ensuring the PES interviewers were not employed as Census field staff in the same area, and vice versa
- maintaining the confidentiality of the PES sample so that Census field and office staff were not aware which areas were included in the PES.

For some people who have not returned a Census form, contact from the ABS following selection in the PES acts as a reminder and possible motivator to return a completed Census form. These late returns, if not identified, would result in the PES sample having a higher proportion of Census response than in the overall population. To protect against this, all Census forms received after the start of PES field work are deemed 'late' and treated differently in PES estimation.

INDEPENDENCE FROM THE CENSUS *continued*

The PES questions are asked of householders face-to-face by experienced, highly trained interviewers, whereas most Census forms are self-completed. The PES is also a much smaller scale operation (and hence easier to control) than the Census. These features enable the PES to deliver an accurate estimate of the percentage of people and dwellings missed by the Census.

The Census can also be used to form an estimate of the percentage of dwellings and people missed by the PES. The PES excludes non-private dwellings (hotels, motels, hospitals) for operational reasons. The PES is also conducted several weeks after the Census, so a respondent's recollection of their location on Census night may not be entirely accurate. Census has special procedures for enumerating homeless people, while the PES is essentially a survey of dwellings and the people who reside in them. Thus the Census may include some dwellings and people that the PES misses. PES estimation implicitly accounts for the dwellings and people missed in the PES but counted in the Census.

On the assumption that the Census and the PES are independent, the estimate of the percentage missed by the PES but found by the Census, and the percentage missed by the Census but found by the PES, can be used to construct estimates of the percentage missed by both PES and Census.

Despite efforts to maintain independence, the likelihood of a person being missed in the PES may be related to whether they were missed in the Census. This may result in a 'correlation bias' in the PES estimates. To minimise this bias, PES estimation takes account of the fact that different groups have a different likelihood of being missed.

SCOPE

The scope of the Census is every person present in Australia on Census night (with the exception of foreign diplomats and their families). Ideally the PES would sample from all people who were or should have been in the scope of the Census, but for practical reasons there are a number of areas, dwellings and people excluded or not able to be covered by the PES. Of the people present in Australia at the time of the PES, the following are not included:

- people in non-private dwellings such as hotels, motels, hospitals and other institutions
- homeless people (as the sample selected in the PES is based on the selection of dwellings)
- foreign diplomats and their families
- overseas visitors who were not in Australia on 8 August 2006 (Census night)
- babies born after 8 August 2006
- people in Cocos (Keeling) Islands, Christmas Island, Australian Antarctic Territory, and Jervis Bay Territory.

The PES does not obtain information about people who died between Census and the PES. However, it does obtain information about Australian residents who are overseas during the PES enumeration period and who departed some time in August, provided that they usually live with people remaining in Australia (in private dwellings).

SCOPE *continued*

The 2006 PES included remote areas and discrete Indigenous communities for the first time. Previous PESs have excluded these areas from the scope of the survey because of operational reasons – mainly the additional cost and the need to use the same local contacts as Census, which was considered likely to compromise the independence of the PES. Inclusion of these communities ensures the geographic scope of the 2006 PES is more complete than it has been in the past.

SURVEY ENUMERATION

THE PES SAMPLE

The 2006 PES sample, which included remote areas and discrete Indigenous communities for the first time, comprised around 40,000 private dwellings (PDs) and 348 dwellings from discrete Indigenous communities (21 discrete Indigenous communities across Northern Territory, South Australia, Queensland and Western Australia). The total number of people enumerated in the PES from these dwellings was around 88,000. The 2001 PES sample included around 37,000 private dwellings and about 84,000 people.

DEVELOPMENT AND TESTING OF COLLECTION PROCEDURES

Several tests of the PES methodology and procedures were conducted prior to the final survey. These tests were used to evaluate and refine questionnaires, field procedures, interviewer workload management systems, ABS regional staff training, field staff training, interview documentation and processing procedures.

An initial pilot test of the PES occurred in Victoria from 14 to 25 September, 2004. A full dress rehearsal of the private dwelling sample was conducted in South Australia from 30 August to 10 September, 2005.

Two tests were conducted for the discrete Indigenous communities sample. The first test was conducted in Western Australia and Northern Territory from 31 October to 2 November, 2005. A second test was conducted in Queensland from 2 to 5 May, 2006.

All tests proved highly beneficial in highlighting areas for improvement for the final PES enumeration conducted in September 2006.

PRIVATE DWELLING QUESTIONNAIRE

The 2006 PES private dwelling questionnaire was based on the 2001 PES questionnaire, with a few minor changes. These were mainly due to the introduction of computer assisted interviewing (CAI) and the addition of automated sequencing and on-line editing, plus the increased capacity to capture more information than was possible with the pen and paper interview method used in 2001.

Specific changes made to 2001 questions for 2006 were:

- the inclusion of questions that asked the relationship of household members
- the capacity to allow for up to 15 usual residents (compared to 6 in 2001)
- the capacity to allow for 11 search addresses (compared to 5 in 2001)
- the inclusion of a dwelling structure question.

DISCRETE INDIGENOUS COMMUNITY QUESTIONNAIRE

CAI methodology was not considered suitable for enumerating discrete Indigenous communities. Instead, a specially designed pen and paper interview (PAPI) questionnaire was used to collect information similar to that collected from private dwellings using the CAI questionnaire. The information collected on PAPI questionnaires was later transcribed to a CAI instrument.

The discrete Indigenous community questionnaire differed from the private dwelling instrument in a number of ways:

Inclusions:

The questionnaire used in discrete Indigenous communities collected the following additional data items:

- up to two alternative names a person is known by
- up to 7 search addresses

SURVEY ENUMERATION *continued*

DISCRETE INDIGENOUS COMMUNITY QUESTIONNAIRE *continued*

- a question relating to whether the person was identified on an administrative list in the community
- the provision for up to 40 persons per household.

Exclusions:

The following items were excluded from the questionnaire used in discrete Indigenous communities:

- questions relating to completion of eCensus forms
- questions about dwelling structure and the existence of households within the dwelling.

Occasionally, wording was altered for the Indigenous questionnaire for ease of understanding. One example of this is 'marital status'. In the private dwelling questionnaire respondents were asked to state their marital status, while people in discrete Indigenous communities were asked whether they were married.

All people, whether Indigenous or non-Indigenous, selected in the PES in discrete Indigenous communities, were interviewed using a paper questionnaire. This meant that interviews could be conducted outdoors. Data was then transcribed into the CAI instrument by the field interviewer at the end of the day, usually after returning to their accommodation.

A community-level questionnaire was asked of the community contact or council officer at discrete Indigenous communities. Information collected included whether any significant event (for example a sports carnival) may have occurred at the time of the Census or at the time PES enumeration was being conducted. This information assisted with respondent recall during the interview and also helped identify other possible Census addresses.

RESOURCES AND FIELD ISSUES

For the private dwelling sample, a panel of 532 specially trained PES interviewers collected data using CAI in face-to-face interviews between 1 September and 24 September 2006. Interviews were conducted with an adult member of the household who was asked to respond on behalf of all members of the household.

The average size of a PES interviewer's workload was 70 dwellings. For the PES, the regular interview panel was supplemented by field-trained office staff to help manage the work and meet the field enumeration deadline.

For the Indigenous component, specially trained ABS office staff, with the assistance of facilitators recruited from within each community, conducted the PES between 11 September and 12 October 2006. A panel of 33 staff (assisted by 29 facilitators) enumerated the PES using a PAPI questionnaire, which was later transcribed to a CAI instrument.

The PES is a large survey requiring 100% face-to-face interviewing. Some of the issues experienced during 'mainstream' (i.e. private dwelling) PES enumeration included:

- difficulty in accessing high-rise and secure apartment buildings
- the potential clash in some Collection Districts (CDs) with Census field staff (see below)
- the need to carefully plan the enumeration of other surveys around that time (e.g. the Monthly Labour Force Survey).

RESOURCES AND FIELD ISSUES *continued*

The 2001 Census saw a significant increase in non-response compared to 1996. For this reason, more intensive follow-up procedures were implemented in 2006, which delayed the end of Census field operations in a small number of CDs by several weeks. This follow-up overlapped with the beginning of PES enumeration in these CDs.

As in previous PESs, special procedures were implemented to identify Census forms received after the start of the 2006 PES field work (late returns). These procedures were needed to preserve the independence of the Census and the PES, as some people may be prompted to return their Census forms following the receipt of the PES primary approach letter (PAL) or the arrival of the PES interviewer.

Enumeration of the discrete Indigenous community component of the 2006 PES required a well-planned sampling and enumeration strategy, since this was the first time enumeration of these communities had been attempted by the ABS for the PES. This strategy included ongoing communication with selected communities (phone, email, brochures and posters) and careful attention to last minute rescheduling of travel and accommodation arrangements.

Enumeration of this component usually involved a two day visit to each community. The PES teams (usually two ABS staff) reported excellent cooperation from all communities. Primary approach letters explaining the nature of the survey were available for households but in most cases were not required. PES posters were displayed in some communities to raise awareness within the community of the forthcoming ABS presence. However, the use of community facilitators was the most successful method for achieving effective cooperation from within the communities.

Some of the challenges faced while enumerating these communities included:

- issues arising from the inability to notify community administrators of their inclusion in the PES until Census field work had been completed in the community
- lack of a specific 'Census night' meant further discussion was required
- the additional work involved in administering a community level questionnaire.

SURVEY ENUMERATION *continued*

FIELD RESPONSE RATE

In the PES, private dwellings and discrete Indigenous communities were separately identified and sampled. Within each state or territory all private dwellings and discrete Indigenous community dwellings had the same chance of selection. The enumeration of the PES private dwelling sample achieved a response rate of 94% compared to 96% in 2001. The response rate for the discrete Indigenous community sample of PES was 92%.

Table 1 shows the achieved number of fully responding dwellings in the two components of the PES sample for each state and Territory.

TABLE 1: ACHIEVED NUMBER OF FULLY RESPONDING DWELLINGS

	<i>Private dwellings</i>	<i>ICF dwellings(a)</i>	<i>Total</i>
New South Wales	7 333	–	7 333
Victoria	6 450	–	6 450
Queensland	5 914	16 (2)	5 930
South Australia	3 800	6 (1)	3 806
Western Australia	4 290	18 (3)	4 308
Tasmania	1 971	–	1 971
Northern Territory	1 622	217 (15)	1 839
Australian Capital Territory	1 349	–	1 349
Australia	32 729	257 (21)	32 986

(a) ICF dwellings are those selected in discrete Indigenous communities. The number in brackets is the number of discrete Indigenous communities from which the ICF dwellings were selected.

MATCH AND SEARCH PROCESSING

OVERVIEW

Processing of the 2006 PES was conducted at the Census Data Processing Centre (DPC) in Melbourne from 13 November 2006 to 2 March 2007.

The match and search process involves comparing dwellings and people enumerated in the PES with dwellings and people found in the Census. The objectives of matching and searching are to determine:

- whether each PES dwelling has been counted or missed in the Census;
- whether each person at the PES dwelling was counted in the Census at that address; and
- whether any people at the PES dwelling were counted in the Census at any other addresses.

The first step in the match and search process is to search the Census file for an address which matches the address of the PES dwelling. When a dwelling is matched, the Census person records for that dwelling are compared with the PES person records. During the person matching step, the information from the PES is compared with information on the Census record to determine whether a person match has been made. Information compared includes name, sex, date of birth, age, marital status, Indigenous status and country of birth. The extent to which each of these characteristics is the same in both the PES and the Census determines whether a match is recorded or not. If a person cannot be found at the particular Census dwelling, a search is conducted for the PES person at the whole of the census dwelling CD.

The final step in the match and search process is to check whether the person was included on a Census form at any other address. The PES questionnaire asks respondents where each person in the household was staying on Census night, and for any other addresses where each person may have been included on a Census form. Census forms for each of these addresses are checked, and the process of person matching repeated, to determine whether the person was included on a Census form at any of these other addresses.

Census undercount occurs when a person included in the PES who was in Australia on Census night and should have been counted in the Census cannot be found on any Census form. Census overcount occurs when a person included in the PES is found on more than one Census form, or when a person is found on a Census form who should not have been included (for example, a person who was overseas on Census night).

THE PES PROCESSING TEAM

The 2006 PES processing team comprised a project manager and, at the peak of processing, 21 processors. These processors were recruited from staff already working at the DPC on various Census activities. Once recruited to the PES they were located in a separate part of the DPC away from other DPC teams.

Working conditions included a mandatory ten minute break every hour and strict rules about attendance, use of mobile phones and general workplace behaviour. All DPC guidelines applied to the PES team, with a few additions designed to ensure independence from the Census.

Training

All PES processing staff underwent a comprehensive training program. The PES training material consisted of:

- Demonstration of the PES field questionnaire – to show PES processors how PES data was collected, including a review of question wording, sequencing and response categories
- Practice exercises with records of varying degrees of difficulty
- PES processing procedures
- PES processing system user guide
- PES processing database – a dedicated database to store all written communication between PES processors and supervisors. Access was restricted to PES staff only.
- Quick reference sheets – dot point lists of key procedures and explanations of some Census codes used in the processing of the PES.
- The 10 PES processing ground rules – a set of guidelines that all PES processors were required to acknowledge and comply with throughout PES processing at the DPC. These procedures were essential for maintaining operational independence from the Census.

THE PES MATCH AND SEARCH SYSTEM (MSS)

The main PES processing facility was called the 'Match and Search System' (MSS), a software system built specifically for PES processing. As the name suggests, the MSS allowed processors to search, view, compare, and record matches between PES and Census data. PES processors used the MSS to record matches of dwellings and people between PES and Census, and to search for people included on Census forms at all alternative addresses provided.

IDENTIFYING DEFAULT SEARCH CDS

Prior to processing at the DPC, an attempt was made to associate each search address with its 2006 CD. This became the default CD for dwelling and person searching.

The 2006 CDs were obtained by submitting the PES search address details to the AddressCoder@ABS Web service (the AddressCoder@ABS returns an Australian Standard Geographical Classification (ASGC) code which is then used to identify an appropriate 2006 Census CD).

Occasionally the information obtained in the PES interview did not contain all the necessary details for the AddressCoder@ABS to return a single CD. In such cases, where a search address could not be isolated to less than 5 CDs, a default CD was chosen by referencing the longitude and latitude coordinates for the geographic centre of the locality. The CD that encompassed these coordinates was chosen as the default CD.

In situations where a search address could be identified to within 5 CDs by the AddressCoder@ABS, the default CD was chosen as the most likely location to commence searching. A number of adjacent CDs were also recorded if wider searching was necessary.

DWELLING MATCHING

An attempt is made to determine whether every dwelling selected in the PES has been counted in the Census. The process involves searching through Census information (e.g. images of Census Collector Record Books) to locate the address of the PES dwelling. This searching is performed at the CD level. The CD number is the key search unit for the MSS.

DWELLING MATCHING

continued

This CD number is used to locate the associated Census Collector Record Book (CRB), which is then displayed on the computer screen for searching. If a search of this CRB does not result in a positive dwelling match, a search is made for the address information on all Census forms in that CD before selecting another CD to search. Resources used to assist in locating the relevant CD for the PES dwelling included an Interactive Spatial Coder (ISC), a 2001-2006 CD concordance, PES dwelling lists and maps, and Census CD maps.

Strict procedures were set to ensure consistency and accuracy when performing the dwelling matching. In order for a dwelling non-match to be recorded, all reasonable attempts had to be made to locate the dwelling in the expected CD, or the neighbouring CDs. All PES dwelling non-matches were confirmed by the PES processing supervisor.

PERSON MATCHING

Once a PES dwelling had been matched to the Census, person matching was carried out for all people in the PES dwelling. In the majority of cases the same people were in the same dwelling during both the PES and Census enumeration, and hence a dwelling match was found to be a strong indicator that the person matching would be successful within the dwelling. When this was not the case, a further search for the PES respondent was carried out at any alternative addresses provided during the PES interview.

In situations where a corresponding Census dwelling could not be found for a PES dwelling, other dwellings in the Census CD were searched in an attempt to locate the residents of the PES dwelling.

To determine if a PES person matched to a Census person, a comparison was made of responses to key variables common to both the PES and Census forms. A field match code (FMC) was recorded to indicate the strength of the match against each of the following fields:

- Name
- Sex
- Date of Birth
- Age
- Marital Status
- Indigenous Status
- Country of Birth
- Relationship in household.

The MSS incorporated an algorithm which combined field match codes to produce a final person match code (PMC). Some variables, such as Name, Sex and Age, have a greater importance in determining the PMC. Other variables, such as Marital Status, Indigenous Status, Country of Birth and Relationship in household were considered less important in determining a PMC but still played a vital part in informing the decision of whether a match existed.

SEARCH ADDRESS PROCESSING

In the PES interview, respondents were asked to provide alternative addresses for where they may have stayed on Census Night, and for where they may have been included on a Census form (whether or not they were staying at that address). These 'search addresses' were used in the person matching process.

MATCH AND SEARCH PROCESSING *continued*

SEARCH ADDRESS PROCESSING *continued*

Search address processing is the final step in determining how many times the PES person was counted in the Census. The process is carried out after the PES dwelling match and the person matching has been completed for all people in the PES dwelling.

The procedures for search address processing are the same as for dwelling and person matching.

VAGUE SEARCH ADDRESSES

Description

Because the PES interview is conducted with one adult member of the household (on behalf of everyone staying there), and because it takes place some weeks after the Census, some of the search addresses may have insufficient detail to make a match to any Census address possible. For instance, the respondent may say 'a hotel in the centre of Sydney', or 'a friend's house in Essendon'. Such addresses are called 'vague search addresses'.

During match and search processing, the general rule for identifying a search address as 'vague' was to look in a minimum of five CDs, that is, the default CD plus four neighbouring CDs. If the dwelling, or person, could not be located within these CDs, and there was a strong likelihood that a comprehensive search would potentially involve a large number of additional CDs, then the search was ceased and that search address was classified as 'vague'. All search addresses set to vague were approved by the PES processing supervisor to ensure a consistent approach across all processing staff and for all states and territories.

The 88,000 respondents to the 2006 PES provided a total of 7,000 search addresses. Of these, approximately 8% (550) were classified as 'vague'. During output processing a modelling technique was used to assign an imputed match status to these records.

Note that only a search address could be classified as 'vague'. The address of a selected PES dwelling was always known and there was no restriction on the number of CDs to be searched in order to confirm whether the Census had counted, or missed, the selected PES dwelling.

Modelling

There is some chance that a PES respondent was counted in the Census at a vague search address, and this must be taken into account in assessing how often they were counted in the Census. However, whether or not the person was counted in the Census at the vague address is unknown because no match to a Census dwelling could be made. The (unknown) number of times counted at a vague address is estimated by a match probability from a model linking probability of being matched with various characteristics of the address and the respondent.

A logistic regression model was used to estimate the match probability for vague search addresses. As in 2001, the model used information from search addresses that were not vague, since for these the match outcome is known. The items considered for inclusion as explanatory variables in the regression included characteristics of the person's PES dwelling (e.g. type of Census form) and of the person themselves (e.g. Indigenous status, age, sex, and whether in scope of the census). The model also accounted for the number of other search addresses the person provided and whether they were matched there, and for whether the vague search address is the address where the person said they were on Census night, the person's usual residence, or another address at which the person may have been counted.

Modelling continued

It is occasionally important to know which Census dwelling a person should have been counted in – this is determined from the address given as the place the respondent spent the night of the Census. For the 2006 PES, if this address was vague, a probability was imputed of this search address being a late return or imputed dwelling. This allows for estimation of numbers of persons who should have been counted in late return and imputed dwellings, separately from other persons.

QUALITY ASSURANCE AND ADJUDICATION PROCESSES

The Quality Assurance (QA) process for the 2006 PES included a 100% recoding exercise by a different processor. There was no identifier on the workloads that allowed the PES processors to know whether they were processing an 'original' or QA workload. Any discrepancies at either the dwelling or person level found between the original and QA processing were automatically flagged by the MSS, and both records were presented to the PES supervisor for adjudication. Adjudication processing was performed in the MSS to ensure consistent procedures were applied when evaluating or reprocessing records.

The PES supervisor reviewed the discrepancies between the original and QA coding and decided which was correct. If the PES supervisor decided that both the original and QA coding were incorrect, the PES record was reprocessed by the PES supervisor.

The QA process was also useful in identifying potential processing issues or areas where processors were having difficulty. This allowed ongoing constructive feedback to be provided to the PES processors and contributed to the overall quality assurance of the PES processing.

DISCRETE INDIGENOUS COMMUNITY PROCESSING PROCEDURES

Discrete Indigenous community processing commenced several weeks after private dwelling processing at the DPC. This allowed more experienced PES processors to be selected for the processing of the Indigenous workloads. Processing of the Indigenous community sample was essentially the same as for private dwellings, with the addition of a few extra processes incorporated to address the particular aspects of discrete Indigenous communities. Problems expected to be encountered in Indigenous communities included the lack of identifiable street addresses, increased mobility between households within a community, and people being known by more than one name.

In order to overcome these potential problems, additional information was collected in the PES Indigenous questionnaire, including:

- alternative names people were known by;
- whether or not people were found on a community administrative list (if so, useful information was noted); and
- a community level questionnaire (CLQ) which was asked of the community contact.

MSS training included a half-day training session on how to use this additional information as part of match and search processing.

The main differences between processing the private dwelling sample and the discrete Indigenous community sample were:

- a search was carried out of the whole community for each person, as well as at each dwelling record within the community (and any outstations).

DISCRETE INDIGENOUS COMMUNITY PROCESSING PROCEDURES *continued*

- for technical reasons, dwelling and person matches were recorded on paper before being entered into the MSS. The primary matching fields, (name/s, sex, age, date of birth, etc.) for each PES respondent were printed for the PES processors to record the Census details of the matched record.
- using search addresses provided in the CLQ for people who could not be found after searching the locations provided during the personal interview.

INDEPENDENT REVIEW OF THE DISCRETE INDIGENOUS COMMUNITY COMPONENT

As this is the first time the ABS has conducted a PES in discrete Indigenous communities, the ABS decided to seek expert advice on the appropriateness of the procedures being proposed for this component of the PES sample.

Professor Stephen Zubrick of the Telethon Institute for Child Health Research in WA was engaged to review and provide comments on the proposed procedures.

Professor Zubrick was provided with relevant PES documentation and visited the DPC site on 10 and 11 January 2007. During his visit, Professor Zubrick observed the PES matching processes for both components of the PES. The key findings from these observations were:

- The documentation was extremely helpful, meticulously prepared and comprehensive.
- The approach for matching and searching, while innovative, was cautious and resulted in minimal to negligible threat to the parity between private dwelling and Indigenous component PES processing.
- The implementation of the PES discrete Indigenous community component required no modification and was on track to contradict the earlier views that a PES Indigenous component could not be done on the basis of the common claims of Indigenous population mobility, changes in names, and difficulties in access to Indigenous communities.

Professor Zubrick's report is available on the ABS website via a link from this information paper.

IDENTIFYING CENSUS LATE RETURNS

Special procedures were implemented for Census forms received after the start of the 2006 PES field work (i.e. 1 September 2006). Any Census form received after this date was flagged as a 'late return' and treated accordingly.

Arrangements were put in place by PES and Census processing management to update a field on the Census file, as required, to identify all types of Census late returns for PES processing. The various types of Census late returns were:

- Mailbacks – forms dispatched by respondents on or after 1 September 2006. For a period of three days, the Census team responsible for initial receipt and registration of Census forms used region and postage time information for different state metropolitan and country areas to identify 'late' forms. All mailback returns received at the DPC on or after 6 September 2006 were flagged as late returns.
- Internet Census – all 'eCensus' forms submitted after 8am (AEST) on 1 September 2006.

MATCH AND SEARCH PROCESSING *continued*

IDENTIFYING CENSUS LATE RETURNS *continued*

- Collector packs and post-collection follow up – PES incorporated specific instructions into Census field documentation reminding collectors and supervisors to mark a field on the back of the Census form for all forms received after 1 September 2006.
- Discrete Indigenous Communities – Communities were reviewed on a case-by-case basis. All Census forms from a community were considered 'early' unless Census failed to enumerate at the first attempt.

ESTIMATION

OVERVIEW

The PES interview process determines whether each person in the sample should have been counted in the Census, and the category in which they should have been counted (such as age, sex, Indigenous status, region of usual residence). The match and search process determines how many times each person in the PES sample was actually counted in the Census. PES output processing and estimation combines and weights results from the match and search process to produce an estimate of the number of people who should have been counted in the Census. Net undercount is the difference between this estimate and the actual Census count (including imputed persons for non-responding dwellings).

Following the 2001 PES, a review of the PES estimation method was commissioned to develop an estimator for the PES that adjusts adequately for non-response and non-coverage in PES and for miscounting in the Census. The estimator used in the 2001 PES did not fully account for people missed in both Census and PES.

One outcome of the review was the development of a new estimator, Prediction Regression (PREG), for use in the person weighting stage of the 2006 PES. Unlike the estimator used in 2001, the weight adjustment applied by PREG to each PES person does not depend on their Census response. The PREG estimator also allows for differences in reporting of a person's characteristics (e.g. age, Indigenous status) between PES and Census.

Information on the technical details of the PREG estimator will be reported in *Research Paper: An estimating equation approach to Census coverage adjustment* (cat. no 1351.0.55.019) released on 7 May 2007.

PES ESTIMATION

Broadly speaking, PES estimation involves assigning a 'weight' to each selected PES dwelling and then to each person for whom a PES response was obtained. The PES estimate of the number of people who should have been counted in the Census is obtained as a weighted sum of the number of people in the PES sample who should have been counted in the Census.

The net undercount for a category of person is obtained by taking the PES estimate of the number of people in the category who should have been counted and subtracting the Census count of the number of people (in the category). Net undercount for a category of person is the net result of the PES estimate of gross undercount, gross overcount, misclassification (e.g. age, sex, Indigenous status) and imputation error in Census.

Dwelling weighting

Dwelling weighting for the 2006 PES comprises two stages. For private dwellings selected in PES that were found in the Census, the first stage of dwelling weighting adjusts the PES selection weight such that the adjusted weights add up to the Census private dwelling count. These adjustments are made within a set of Census dwelling categories based on region, dwelling structure and type of Census response (single occupant, multiple occupant, unoccupied, non-contact sector). A first-stage weight adjustment is also applied to private dwellings selected in PES that were missed in the Census. These dwellings receive the average adjustment across all categories of type of Census response (for the same region). For dwellings in discrete Indigenous communities, a

Dwelling weighting continued

similar first-stage weight adjustment is applied, except that Census dwelling categories are based only on state or territory of the community.

The second stage of dwelling weighting applies a non-response adjustment so that the responding PES dwellings represent other dwellings from which no response was obtained. These adjustments are also made within a set of Census dwelling categories based on region, dwelling structure and type of Census response. For discrete Indigenous communities, a single overall adjustment is applied in each state and territory.

Other improvements made to the PES dwelling weighting for 2006 include:

- New Census response categories have been introduced: Occupied dwellings are now split into 'single-occupant' and 'multiple-occupant', and a category has been introduced for discrete Indigenous community dwellings.
- Dwelling structure is introduced as a benchmark category in weighting (for non-ICF dwellings matched to the Census).
- Partially-responding dwellings are treated as responding dwellings, so that the responding people in these dwellings can be included in person weighting and estimates.
- Weighting for 'Late Returns and Imputed Dwellings' is now designed to make these dwellings representative of this combined group in the Census.
- Northern Territory is treated as two regions (Darwin/Balance of Territory).

Person weighting

Estimates of the number of people who should have been counted in the Census based on the dwelling weights would only represent the population of people who were in private dwellings at the time of PES. That is, they would underestimate the private dwelling population at the time of the Census because some people in private dwellings on Census night will be in non-private dwellings, overseas, or may even be deceased at PES time. Such estimates would also not represent people living in non-private dwellings. To represent all in-scope people on Census night requires adjusting the dwelling weights to give a person weight.

The initial person weight adjustments (from the PREG estimator) are chosen to ensure that the PES estimates of people counted in private dwellings (other than late return or imputed dwellings) in a set of benchmark categories match the actual Census counts for these categories. The variables used to form these benchmark categories are region, sex, age (by 16 age groups), country of birth, marital status, Indigenous status, and whether sampled in an ICF dwelling. The weight adjustment applied to a person does not depend on whether they responded in the Census, but only on characteristics of the person as reported in the PES. In 2001, the PES estimator used for weighting made weight adjustments reliant on whether a person responded in the Census, and assumed people were recorded in the same categories in PES and Census (i.e. same age, sex, region, etc.).

As a final step in weight adjustment, the initial person weights are adjusted (using the PREG estimator) so that the PES estimates represent people in non-private dwellings as well as private dwellings. This final step uses region, age and sex only, as information on other items is not reliable for non-private dwellings.

ESTIMATION *continued*

Person weighting continued

For the initial stage of person weighting, data items used to form benchmark categories include Indigenous Status and Country of Birth. However, one or both of these may be 'not-stated' (i.e. blank) for a number of Census records where people have not responded to these items in the Census. In these cases a value needs to be imputed so that these items can be used for initial person weighting.

Estimating the number of people in Census late return and imputed dwellings

For some people who have not returned a Census form, contact from the ABS following selection in the PES acts as a reminder and possible motivator to return a completed Census form. These late returns, if not identified, would result in the PES sample having a higher proportion of Census response than in the overall population. To protect against this, all Census forms received after the start of PES field work are deemed 'late'. For the purpose of PES estimation, the dwellings from which these forms are received are treated as though they had not been contacted in the Census, and are classified to the 'non-contact sector' of the Census.

The non-contact sector also contains dwellings which were non-responding in the Census – that is, dwellings where the Census never obtained a return, and which could not be established as having been unoccupied on Census night. These non-response dwellings are given imputed values (using 'hot-deck' imputation) during Census processing, based in many cases on information provided by the Census collector about the dwelling and its residents. Inevitably, the imputed values, at the dwelling and aggregate level, differ from the true, but unknown, values. The imputed records constitute the majority of the Census non-contact sector records; late returns (as defined here) are only a small component of the overall Census non-contact sector. Given that late returns prompted by PES would otherwise have been classed as non-response in the Census, the PES sample is representative of the whole non-contact sector, even though it cannot split late returns from non-responses in a manner comparable to the Census.

In previous Censuses, only the Census contact sector was corrected for under- and over-count by using the PES estimates. Effectively, late returns and imputed dwellings (the Census non-contact sector for PES purposes) were treated as being reported accurately. While this assumption is imperfect, this was considered the most feasible way to calculate accurate net undercount estimates at the level of detail needed for producing estimated resident population counts in Australia.

For the 2006 PES, the person weighting step in PES processing calculates weights for all PES records, including those that correspond to the Census non-contact sector. Hence the PES can provide an estimate of the total population in Census late return and non-response dwellings on Census night. This is a change from previous PESs, in which persons selected in non-contact sector dwellings were excluded from matching and from estimation. The inclusion of these persons in the 2006 PES is an innovation made possible by the development of appropriate methods for representing them in estimation.

Estimates for the non-contact sector have relatively high sampling errors because of the small sample size (there are relatively few non-contact dwellings selected by chance in the PES sample); and also because person counts for this sector are not available to use as a weighting 'benchmark'. This lack of Census person counts also means that, while the dwelling weights used for the non-contact sector are estimated from the sector itself,

ESTIMATION *continued*

Estimating the number of people in Census late return and imputed dwellings continued

the adjustments applied to provide final person weights depend strongly on information observed in the contact sector. This is a potential source of non-sampling error, as is any bias arising from peculiarities of the non-respondents in this sector. Both these sources of non-sampling error are expected to be small compared to the sampling error of the non-contact sector estimates.

Using PES estimates for the population of the non-contact sector leads to a rise in the standard error of the overall population estimates. On the other hand, the alternative, where this sector is not measured by PES but is treated as accurately represented by the Census figures, can have a bias associated with Census imputation for non-contacts. Since the standard error for the non-contact sector estimate can be calculated, it is possible to compare the comparative accuracy of the estimate based on PES, and the Census count for the late return and imputed dwellings.

For the 2006 PES, the PES estimate for the non-contact sector is considered to be a better estimate than the Census count for this sector, as the increase in standard error has less impact than the bias that would arise from unadjusted inaccuracies in the Census imputation process.

HOW NET UNDERCOUNT CONTRIBUTES TO ERP

BACKGROUND

The estimated resident population (ERP) is the official estimate of the population of Australia calculated by the ABS at quarterly intervals each year.

Following each Census, the ERP for 30 June of the Census year is rebased using the Census data, adjusted by PES data and other information.

CALCULATION OF REBASED ERP

Initially, a count of Australian residents in Australia on Census night is obtained by excluding all overseas visitors enumerated in the Census.

This Census count is then augmented to produce an estimate which accounts for net undercount. Net undercount is the net result of people who were missed by the Census, and people who were counted more than once in the Census (or counted at all when they should not have been). The data source for this estimate of net undercount is the PES.

ERP calculations then make an allowance for Australian residents who were temporarily absent from Australia on Census night. This estimate is made using data from completed passenger cards, visa and passport information obtained from the Department of Immigration and Citizenship, and these people are added into the Australian resident population.

The final step in calculating ERP is to backdate it to 30 June of the Census year. This is achieved by adding the deaths and subtracting the births and net overseas migration which occurred between 1 July and the Census date. Table 2 shows the components used to calculate rebased ERP for Australia from the 2001 Census.

TABLE 2: COMPONENTS OF ERP, Australia, 30 June 2001

	<i>Persons</i>
<i>Components of ERP</i>	'000
Census count, actual location	18 972.4
less Overseas visitors	203.1
Census count, place of usual residence	18 769.2
plus Net undercount(a)	346.2
plus Residents temporarily overseas	330.2
ERP as at 7 August 2001	19 445.6
less Births (1 July to 7 August 2001)	25.4
plus Deaths (1 July to 7 August 2001)	14.8
less Net overseas migration (1 July to 7 August 2001)	21.8
ERP as at 30 June 2001	19 413.2

(a) Includes demographic adjustments.

Information on the calculation of rebased ERP for 30 June 2006 based on the 2006 Census will be reported in *Australian Demographic Statistics, December quarter 2006* (cat. no. 3101.0), due for release on 5 June 2007.

DEMOGRAPHIC ADJUSTMENTS

While the PES identifies people and dwellings missed in the Census, the extent to which some people are missed in both the Census and the PES may not be fully accounted for in PES estimation, resulting in a possible 'correlation bias'. As in any survey, the PES is also subject to sampling and non-sampling error. To offset the impact of correlation bias

HOW NET UNDERCOUNT CONTRIBUTES TO ERP *continued*

DEMOGRAPHIC ADJUSTMENTS *continued*

and survey error, population estimates derived from the PES are further refined using demographic adjustments based on independent sources of population information: birth and death registrations, Medicare enrolment numbers, and the estimated resident population based on the previous Census carried forward.

For further information on demographic adjustment used in conjunction with the results of the PES, see *Australian Demographic Statistics, December quarter 2006* (cat. no. 3101.0), due for release on 5 June 2007.

GLOSSARY

Benchmark category	A category of dwelling or person for which the PES estimate of the Census count is forced to reproduce the actual Census count.
Census collection district (CD)	A Census collection district (CD) is the basic geographic unit of collection in the Census. A CD is generally a Census workload area that one collector can cover, delivering and collecting forms in a specified period. On average there are about 200 dwellings per CD; however, there may be more in some urban CDs, and in rural areas a CD may contain fewer dwellings yet cover an extensive area.
Computer Assisted Interviewing (CAI)	Computer-assisted interviewing (CAI) is a method of data collection whereby responses are recorded directly into an electronic questionnaire on a notebook computer.
Contact sector	The Census contact sector comprises all Census dwellings, excluding late return and imputed dwellings.
Correlation bias	A bias arising when people who are not counted in the Census are more likely to be missed in the PES than people (with similar values of the characteristics used in PES estimation such as age, sex and Indigenous status) who are counted in the Census.
Coverage	Survey coverage refers to the population units which have a chance of being selected in the survey sample. For the quality of the survey estimates, it is desirable that the survey coverage matches as closely as possible the survey scope. Coverage rules are generally applied in all household surveys to ensure that each person is associated with only one dwelling, and hence has only one chance of selection.
Discrete Indigenous community	A discrete Indigenous community is defined as a geographic location, bounded by physical or legal boundaries, and inhabited or intended to be inhabited predominantly by Indigenous people, with housing or infrastructure that is either owned or managed on a community basis.
Estimated Resident Population (ERP)	Estimated Resident Population (ERP) is the official measure of the population of Australia based on the concept of residence. It refers to all people, regardless of nationality or citizenship, who usually live in Australia, with the exception of foreign diplomatic personnel and their families. It includes usual residents who are overseas for less than 12 months. It excludes overseas visitors who are in Australia for less than 12 months.
ERP rebasing	Following each Census of Population and Housing, ABS rebases its official estimates of population – the Estimated Resident Population (ERP) series. This provides the basis for population estimates until the next Census. The rebased Census-year ERP together with other Census information and data on intercensal components of population change allows ERP revisions to be made back to, but not including, the previous Census.
Hotdeck imputation	An imputation process whereby a donor record is located and relevant responses copied from the donor record to a non-responding record. The donor record will have similar characteristics to the non-responding record and must also have the required variable(s) stated. In addition, the donor record will be located geographically as close as possible to the location of the record to be imputed. When a suitable match is found, then the copying of the response(s) from the donor record to the variable(s) that have missing values can occur.
Indigenous Community Frame (ICF)	<p>The Indigenous Community Frame (ICF) is a listing of all discrete Indigenous communities from which the sample of communities was selected for the 2006 PES. The selection unit on the ICF is a community set. A set usually comprises a main community, a number of out-stations and the non-community dwellings within the CDs associated with the main community. If a community set is selected then a selection of the dwellings in the main community, all the dwellings in some outstations, and a selection of the non-community dwellings will be enumerated in the survey.</p> <p>Once a community set has been selected the main community dwellings and outstations that will be enumerated are determined by the community skip and a random start. For instance, suppose a selected community set has 25 dwellings, 8 outstations and a skip of</p>

GLOSSARY *continued*

Indigenous Community Frame (ICF) <i>continued</i>	5. The random start assigned is 3. The dwellings selected for enumeration are 3, 8, 13, 18, and 23, and all of outstations 3 and 8. The non-community dwellings will be enumerated with a skip of 5.
Imputation	A statistical process for predicting values where no response was provided to a question and a response could not be derived.
Imputed dwelling (in Census)	A dwelling which is considered to be occupied in the Census, and where Census data is imputed because no Census form was received.
Interactive Spatial Coder (ISC)	The Interactive Spatial Coder (ISC) is an ABS application (a type of virtual mapping software) that allows the user to search for an address to identify its CD and those adjacent to it. The ISC was the most commonly used tool in PES processing to successfully locate the actual 2006 CD of a PES dwelling when the default CD proved incorrect.
Late return	A Census form which was returned after the start of PES enumeration.
Mainstream	The term 'mainstream' refers to the PES private dwelling sample, that is, all PES selections other than those from discrete Indigenous communities.
Non-contact sector	The Census non-contact sector comprises late return and imputed dwellings.
Non-private dwelling	An establishment which provides a communal type of accommodation, such as a hotel, motel, hospital or other institution. Non-private dwellings were not included in the 2006 PES sample.
Non-sampling error	Non-sampling error arises from inaccuracies in collecting, recording and processing the data. Every effort is made to minimise non-sampling error by the careful design of questionnaires, intensive training and supervision of interviewers, and efficient data processing procedures. Non-sampling error also arises because information cannot be obtained from all persons selected in the survey.
Outstation (or homeland)	A discrete Indigenous community that has a population of less than 50 people AND is administered by, or linked to, an organisation such as a Resource Agency or larger parent discrete Indigenous community for the provision and maintenance of services.
Private dwelling	A private dwelling is a residential structure which is self-contained, owned or rented by the occupants, and intended solely for residential use. A private dwelling may be a flat, part of a house, or even a room, but can also be a house attached to, or rooms above shops or offices.
Remote areas	<p>Within the Australian Standard Geographical Classification (ASGC), the Remoteness classification comprises five categories, each of which identifies a (non-contiguous) region in Australia having a particular degree of remoteness. The categories range from 'highly accessible' to 'very remote'.</p> <p>The degree of remoteness of each Collection District (CD) was determined using the Accessibility/Remoteness Index of Australia (ARIA). CDs have then been grouped into the appropriate category of Remoteness to form non-contiguous areas within each State.</p> <p>For more information, refer to <i>Statistical Geography Volume 1: Australian Standard Geographical Classification (ASGC) 2001</i> (cat. no. 1216.0) and <i>ABS Views on Remoteness</i> (cat. no. 1244.0).</p>
Sampling error	Sampling error occurs because a sample, rather than the entire population, is surveyed. One measure of the likely difference resulting from not including all dwellings in the survey is given by the standard error. There are about two chances in three that a sample estimate will differ by less than one standard error from the figure that would have been obtained if all dwellings had been included in the survey, and about nineteen chances in twenty that the difference will be less than two standard errors.

GLOSSARY *continued*

Search address	An address where a person was reported to be staying on Census night or where a person may have been included on a Census form. PES processing attempts to locate a Census form for each search address, in order to determine the number of times (if any) a person enumerated in the PES was included on a Census form.
Scope	Within household surveys in the ABS, survey scope is considered to be the population about which inferences are desired: that is, when the results are published, the population to which they refer.
Unoccupied dwelling (in Census)	A structure built specifically for living purposes which is habitable but the Census Collector was certain was unoccupied on Census night.

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