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Assessing the accuracy of Australia's small area population estimates, 2001

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Abstract
In Australia, the Statistical Local Area (SLA) is the base spatial unit used to collect and disseminate statistics other than those collected from the Population Census. The Australian Bureau of Statistics prepares population estimates for SLAs annually.

Data from the 1996 Census was used to produce SLA population estimates for 1996. These were used as a base to calculate preliminary estimates for 1997 to 2001, by applying estimation techniques using data sources such as buildings approvals and Medicare enrolments.

Following the release of 2001 Census data, population estimates for 2001 were recalculated. These are customarily adopted as the 'true', or final, 2001 estimates.

The differences between the preliminary and final 2001 estimates are, essentially, a measure of the accuracy of the preliminary estimates. This paper investigates these differences, providing an interesting insight into the quality of Australia's small area population estimates.

The paper assesses the accuracy of these estimates over time, and notes an overall improvement in the quality of the estimates in 2001. The paper also analyses the accuracy of the 2001 estimates based on factors such as: the inherent characteristics of the region (such as its population size, structure and growth rate); the quality of the input data; and the estimation method.

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1 SMALL AREA POPULATION ESTIMATES IN AUSTRALIA

1.1 Overview

The Australian Bureau of Statistics (ABS) compiles and publishes estimates of the population and its components. Here, population is defined according to the concept of Estimated Resident Population (ERP), which links people to their place of usual residence within Australia. Population estimates are of fundamental importance to the community and receive specific mention in the *Census and Statistics Act 1905*.

ERPs are produced annually for Statistical Local Areas (SLAs). The SLA is the base spatial unit used to collect and disseminate statistics other than those collected from the Population Census. SLAs cover the whole of Australia without gaps or overlaps.

Population estimates for SLAs – which conform to, or combine to form, Local Government Areas (LGAs) – are fundamental data. They are critical for state and territory local government grants bodies and local government authorities. In addition, population estimates for SLAs are used as a base for population projections. ABS population surveys use SLA–based population estimates and projections as benchmarks for output. SLA population estimates and projections are also used extensively by electoral commissions, health analysts, in private enterprise and for research purposes.

ERPs for SLAs are produced annually, as at 30 June. The ABS first publishes SLA population totals, which are generally released about seven months after the reference date. Later these SLA population totals are disaggregated into age and sex components, and are generally released within twelve months of the reference date. This paper focuses on the population totals.

Annual LGA/SLA population estimates (or the previous equivalents) have been published for New South Wales and Queensland since 1911, Victoria since 1875, South Australia since 1915, Western Australia since 1926, Tasmania since 1923, the Northern Territory since 1981 and the Australian Capital Territory since 1968.

1.2 Method

The method used to produce the annual SLA population estimates depends on whether a Census of Population and Housing was conducted that year.

SLA population estimates – census years

Census counts of usual residents, validated in conjunction with regional offices of the ABS, are used to produce ERPs for SLAs as at 30 June of the census year. These ERPs are derived from the census counts by:

applying demographic adjustments where known problems exist with the census data;

adjusting for net undercount using data from the census Post–Enumeration Survey [1];

[1] The Post–Enumeration Survey (PES) is a sample survey conducted immediately after the census to estimate the number of people (and their characteristics) who did not complete or were not included on a census form. It also detects the (rarer) instances of double counting of individuals. The net undercount is therefore the excess of the undercount (people not counted) over the number of those double counted. In 2001 the net undercount for Australia was 1.6 per cent. For each SLA, the PES adjustment takes into account: part of state (capital city/rest of state), age, sex and indigenous status (ABS 2003a).

estimating the number of Australian residents temporarily overseas (derived from residential addresses reported by these residents upon returning to Australia after the census), which are added to the appropriate SLAs;

if the census does not occur on 30 June, for example the 2001 Census was held on 7 August, then an adjustment is made to produce estimates at the nearest 30 June reference date (a variation of the component method[2] is used for this adjustment).

SLA population estimates – non–census years

Based on census year SLA population estimates, ERPs for SLAs are updated as at 30 June in following years.

Although annual births and deaths data are available for SLAs, the absence of good quality migration data for non–census years means that it is not feasible to use the component method[2] to update SLA population totals.

Instead, for most SLAs, a mathematical model is used to estimate SLA populations. This model establishes a relationship, based on past data, between population change and the change in symptomatic indicator variable(s). Symptomatic indicators are any available set of data which in some way relates to changes in population size. The choice of indicators varies across regions and types of SLAs, and includes dwelling approvals, Medicare enrolments, drivers licenses and electricity connections. The relationship between population change and symptomatic indicators are expressed mathematically in terms of regression coefficients which, with the knowledge of the change in the indicators for the estimation period, enable population change to be estimated.

All modelled estimates are validated and adjustments may be made to these modelled estimates after taking into account other indicator data, other methods and procedures, and/or advice provided by local experts. Some areas, for example those areas where there are difficulties in obtaining reliable indicator data, or very small areas, may not be modelled at all; instead these areas may have their estimates derived using other means, or even held constant over the estimation period.

State/territory estimates are derived separately and earlier than the SLA estimates. All SLA estimates are constrained to add to these previously derived state/territory population totals.

Since the 1997 series of estimates, ERPs for all SLAs in Australia for non–census years have been calculated by the Small Area Population Unit (SAPU), located in the Adelaide office of the ABS. Despite the centralised production of SLA population estimates, each state and territory office of the ABS validates the provisional figures produced by the SAPU, and has the discretion to adjust these figures. After the estimates have been validated, they are regarded as preliminary, and are released as soon as possible.

These methods and procedures are detailed in ABS Demography Working Paper 2000/3 *Methods and Procedures for Estimating Small Area Populations in Australia* (ABS 2000).

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[2] The component method is the fundamental demographic equation, which says that the population at a point in time equals the population at a previous point in time, plus/minus the components of population change: births (added), deaths (subtracted) and net migration (added/subtracted), which occurred between these two points in time.

1.3 Release

Generally, three series of SLA estimates are produced. The release procedure again depends on whether a census is conducted in that year.

The three series generally fall under the categories of *preliminary*, *revised*, and *final*.

SLA population estimates – census years

In the interests of providing timely data, *preliminary* ERPs, updated from the previous census, are calculated. Later, when some census results become available, *revised* estimates for the census year are made. When final census results are available and state/territory totals are finalised, *final* ERPs for SLAs are produced.

TABLE 1: TIMETABLE FOR RELEASE OF ESTIMATED RESIDENT POPULATION, STATISTICAL LOCAL AREAS, 30 JUNE 2001

Type	*Comment*	*Release date*
Preliminary	Updated from 1996 Census–based estimates	February 2002 (ABS 2002a)
Revised	Based on release of some 2001 Census data	July 2002 (ABS 2002b)
Final	Based on release of all/final 2001 Census data	April 2003 (ABS 2003b)

SLA population estimates – non–census years

As is the case in census years, *preliminary* ERPs in non–census years are published seven to eight months after the reference date.

When state/territory totals are revised (about 15 months after the reference date), *revised* SLA totals are also calculated, to add to new state/territory totals. This revision is usually made by pro–rating the preliminary SLA estimates to the revised state/territory total. However these adjustments to preliminary SLAs are, in most cases, fairly minimal, because revisions to the state/territory totals are usually very small.

Once the following census year ERPs have been finalised, and to overcome the break in continuity between the two data series (ie. preliminary non–census year and final census year estimates), all ERPs updated from the previous census are then recalculated to become *final*. In doing so, the error as at the census year to assumed to have accumulated by an equal amount each year over the intercensal period. Final ERPs for SLAs as at 30 June 1997 to 2000 were released in April 2003 (ABS 2003b).

1.4 Population distribution

It is important to become familiar with the distribution of SLA size (in terms of population) in each state/territory.

The nature of SLA geography across Australia is such that SLAs range in population size from zero to almost 200,000 persons. The SLA with the largest population in 2001 was Wollongong (C), with 189,776 persons. Several SLAs had zero population in 2001.

The SLAs included in this analysis are those as defined by the 2001 Australian Standard Geographical Classification (ABS 2001), excluding the three SLAs that make up 'Other Territories'.

TABLE 2: DISTRIBUTION OF STATISTICAL LOCAL AREAS BY POPULATION, 30 JUNE 2001

	Number of SLAs by population size, 30 June 2001									*ERP 30 June 2001 ('000)*		
	zero	1–499	500–2000	2000–4999	5000–9999	10000–19999	20000–49999	50000+	**Total SLAs**	Total	Mean	Median
NSW	1	3	8	47	33	24	40	43	**199**	6,575.2	33.2	11.9
Vic	3	1	2	34	47	35	49	29	**200**	4,804.7	24.1	12.0
Qld	2	14	54	129	129	101	22	3	**454**	3,628.9	8.0	5.7
SA	3	5	13	21	24	28	31	0	**125**	1,511.7	12.2	8.6
WA	1	14	58	24	14	15	19	11	**156**	1,901.2	12.3	2.9
Tas	1	2	6	10	11	8	5	1	**44**	471.8	11.0	5.7
NT	1	3	14	38	8	1	0	0	**65**	197.8	3.1	2.6
ACT	1	20	12	60	13	1	0	0	**107**	319.3	3.0	2.9
Australia(a)	13	62	167	363	279	213	166	87	**1,350**	19,410.7	14.5	6.1

(a) Excluding Other Territories.

In 2001, the six states had a mean SLA ERP much larger than the median, indicating that in those states, a relatively small number of SLAs had a relatively large proportion of the population. In fact, over 50 per cent of the populations of Western Australia and New South Wales resided in only 8 and 12 per cent of SLAs respectively. At the other extreme, in both the Australian Capital Territory and the Northern Territory (where the median SLA size was much closer to the average SLA size), half of their population was in 26 per cent of SLAs.

2 ASSESSMENT

2.1 Overview

To assess the accuracy of the estimates, the preliminary SLA population estimates are compared with the final estimates for the census year. The difference between the preliminary and final census year estimate is referred to as the **intercensal error**[3]**.**

One or more of three aspects may contribute to the intercensal error:

errors in the census–based population estimate at the previous census (the base): unless identified and acted upon, any estimate which has been updated from an erroneous base will carry the error onwards;

errors in the census–based population estimate at the current census (the end–point): an erroneous final estimate reduces the legitimacy of any comparison with this figure;

errors in the preliminary census–year estimate: provided the estimates for the base and end–points are legitimate, the error can then be a measure of the quality of the preliminary estimate – its method type, application, indicator data etc.

Errors in Australia's census–derived estimates are difficult to detect. While the PES can provide an indication of how many people were missed (or double–counted) by the census (section 1.2), this survey – which is already the largest survey conducted by the ABS – is not large enough to provide measures of net census undercount at the SLA level. Errors in the base may also creep in due to other factors, such as residents temporarily overseas not being properly assigned to their SLA of usual residence.

[3] If the intercensal error is adjusted for revisions to components of population change data, the remaining (unattributable) portion is known as the intercensal **discrepancy**; thus the intercensal discrepancy acts as a balancing item, that when combined with births, deaths and migration equals the change in the intercensal population estimates. However, due to difficulties in measuring migration at the SLA level, it is not possible to calculate the discrepancy at the SLA level. The current method of estimating at the SLA level, where births and deaths are not directly used, also makes calculation of the discrepancy not feasible.

However it is generally regarded that Australia's census–derived data is of good quality and, for the purpose of this analysis, the census–derived base (1996) and final (2001) estimates are implicitly assumed to be correct.

The intercensal error is a useful indicator of the performance of the method used to calculate all ERPs since the previous census. The 30 June 2001 intercensal errors are not only a measure of the differences between preliminary and final ERPs in 2001, it reflects the accuracy of all population estimates produced for those regions since 1997.

The preliminary 2001 SLA population estimates were those published in *Regional Population Growth, 2000–01*, released February 2002 (ABS 2002a). The final 2001 ERPs were released by the ABS in April 2003 (ABS 2003b).

Measures of error

Several measures of intercensal error can be considered. The most common measure is the *percentage* difference between the preliminary and final estimates. However, the *numeric* difference may also be useful. Other difference measures can be obtained by transforming the differences, for example, by dealing with the *log* of the difference.

TABLE 3: MEASURES OF ERROR

Type of error	*Formula, where* P_p = preliminary ERP P_f = final ERP	*Example, where:* P_p = 10,500 P_f = 10,000
Percentage error	$\frac{100 \times (P_p - P_f)}{P_f}$	5%
Numeric error	$P_p - P_f$	500 persons
Log error	$\frac{\log(P_p - P_f)}{\log(P_f)}$	0.675

The sizes of errors tend to relate to the size of the populations being considered; for instance, numeric errors for small numbers tend to be small, percentage errors for small numbers tend to be large. This aspect can cloud the error as an effective measure of accuracy. Table 4 considers various measures of error associated with populations of size 2,000, 20,000 and 200,000.

TABLE 4: EXAMPLES OF ERRORS AND MEASURES OF ERROR ASSOCIATED WITH POPULATIONS OF SIZE 2,000, 20,000 AND 200,000

Population		*Type of error*		
Final	Preliminary	Percentage	Numeric	Log(a)
		***PERCENTAGE** ERROR = +5 per cent*		
2,000	2,100	*5.0*	100	0.61
20,000	21,000	*5.0*	1,000	0.70
200,000	210,000	*5.0*	10,000	0.75
		***NUMERIC** ERROR = +1000 persons*		
2,000	3,000	50.0	*1,000*	0.91
20,000	21,000	5.0	*1,000*	0.70
200,000	201,000	0.5	*1,000*	0.57
		***LOG** ERROR = 0.67*		
2,000	2,163	8.1	163	*0.67*
20,000	20,762	3.8	762	*0.67*
200,000	203,562	1.8	3,562	*0.67*

(a) The 'log' error is defined as the logarithm of the error divided by the logarithm of the final ERP.

Evaluation based purely on one measure of error assumes that each region's error is as significant as each other's, despite the range of sizes. Thus, when evaluating errors across regions with a wide range of population sizes, care should be taken to ensure that no particular group of regions (in terms of size) is disadvantaged by conclusions made for other groups.

In 2001, SLAs in Australia ranged in size from zero to almost 200,000 persons, and average SLA sizes across the states/territories varied significantly (section 1.4). The wide range of SLA sizes across (and within) states/territories means that it is not feasible to compare errors across (and within) states/territories, based on only one type of error.

When combining a number of errors to produce a consolidated figure such as the average SLA intercensal error for a state, the *absolute value* of the errors must be used. If both positive (over–estimates) and negative (under–estimates) errors were added together, the errors may well cancel each other out, leading to a meaningless summary figure.

What is an acceptable error?

The examples provided in table 4 show that the establishment of a threshold error is not clear. For a small area, an error of five per cent might be 'acceptable', for example an error of 100 in an area of 2,000 persons. However, an error of five per cent in an area of 200,000 persons (10,000) is probably less acceptable. Due to the highly variable nature of SLAs, this paper avoids the concept of an 'acceptable' or 'unacceptable' error.

Types of error – pros and cons

The concept of the *percentage* error is simple and widely understood. However percentage errors are not suited to analysis of SLAs which have a wide range of populations, and/or for small SLAs, since percentage errors are generally higher for small SLAs.

Numeric errors are even more straightforward. Again however, evaluation purely based on numeric error is not suited to groups of SLAs with a large range of populations, and/or for large SLAs. Numeric errors are generally higher for large SLAs.

A logarithmic transformation may be considered a 'compromise' between a percentage and numeric error, because large SLAs are scaled downwards more than small SLAs. However the '*log*' error tends not to be widely used, probably because the concept of the log error (including the choice of a threshold value) is more difficult to understand.

An important consideration when evaluating discrepancies should be the effect that one area's error has on other areas. This is especially relevant when funds are allocated based on the share of the total state/territory population that each area has. For instance, if a relatively large LGA was significantly over–estimated, then the remaining LGAs would receive less share of the available pool of funding. Nash (1950) attempts to account for this by deriving a criterion function which recognises the need to choose an allocation scheme which is a jointly acceptable compromise for all members of a community. This function suggests that a *chi–squared* statistic may be a more appropriate measure of error.

Despite its shortcomings, the traditional measure of intercensal error is the percentage error. The tendency for percentage error to over–emphasise the degree of error for small SLAs may be reduced by simply excluding very small SLAs from analysis. In evaluating the accuracy of population estimates, the remainder of this paper will focus mostly on the percentage error.

2.2 Assessment of Australia's population estimates, 2001

National, State and Territory

The initial preliminary ERP of Australia at 30 June 2001, derived by updating the 1996 census–based estimate, understated the 2001 census–based population by 26,600[4]. In other words, the national preliminary intercensal error was –26,600, or –0.14 per cent. The size and direction of errors varied across the states/territories, as displayed in table 5.

TABLE 5: INTERCENSAL ERRORS, PRELIMINARY, STATES/TERRITORIES & AUSTRALIA, 30 JUNE 2001

	Estimated Resident Population ('000)		*Error (a)*	
	Preliminary(a)	Final	Number ('000)	*Per cent*
NSW	6,532.5	6,575.2	–42.8	–0.65
Vic	4,829.0	4,804.7	+24.2	+0.50
Qld	3,627.8	3,628.9	–1.1	–0.03
SA	1,502.4	1,511.7	–9.3	–0.62
WA	1,909.8	1,901.2	+8.6	+0.45
Tas	470.3	471.8	–1.5	–0.32
NT	197.6	197.8	–0.2	–0.09
ACT	314.2	319.3	–5.1	–1.61
Australia(b)	19,386.7	19,413.2	–26.6	–0.14

(a) Based on projected overseas migration data.
(b) Including Other Territories.

Population estimates at below the state/territory level are generally produced at the SLA level, then aggregated to broader regions (Local Government Area, part of state, etc).

Statistical Local Areas

In line with the under–estimate of the total Australian population, a larger number of SLA totals were under–estimated (negative error) than were over–estimated (positive error). In 2001 there were 752 SLAs under–estimated, compared with 580 over–estimated.

TABLE 6: DIRECTIONS OF INTERCENSAL ERRORS, STATISTICAL LOCAL AREAS, 30 JUNE 2001

	Number of SLAs(a)	*SLAs over–estimated*		*SLAs under–estimated*	
		Number	Per cent	Number	Per cent
NSW	198	47	23.7	151	76.3
Vic	197	82	41.8	114	58.2
Qld	452	210	46.6	241	53.4
SA	122	53	43.4	69	56.6
WA	155	89	57.4	66	42.6
Tas	43	23	54.8	19	45.2
NT	64	29	45.3	35	54.7
ACT	106	46	44.7	57	55.3
Australia	1,337	579	43.5	752	56.5

(a) Excludes SLAs where final ERP was zero; six other SLAs had zero intercensal error in 2001.

[4] The preliminary figures used to calculate the intercensal errors in table 5 did not incorporate overseas migration for 2000–01. Instead, projected migration data was used. Later, when 2000–01 migration data was available, the preliminary ERP was recalculated, and the national intercensal error was **+10,550**, or +0.05 per cent (ABS 2003c). However, SLA populations were not updated this way, and so the initial preliminary state/territory population figures, based on projected migration, are used in this analysis.

In 2001, 75 per cent of SLAs in Australia had an intercensal error of less than five per cent. In all states/territories except the Northern Territory, 66 per cent or more of the preliminary SLA estimates were within five per cent of their final figures. Victoria had the highest percentage of SLAs with less than five per cent error (87 per cent of SLAs in Victoria), while the Northern Territory had the lowest percentage (52 per cent). Tasmania had the highest percentage of preliminary SLA estimates within two per cent of their final ERP (53 per cent); the Northern Territory had the lowest percentage (27 per cent).

TABLE 7: INTERCENSAL ERRORS (IEs), STATISTICAL LOCAL AREAS, 30 JUNE 2001

	Number of SLAs (a)	*0% ≤ ie < 2%*		*2% ≤ ie < 5%*		*ie ≥ 5%*	
		Number	Per cent	Number	Per cent	Number	Per cent
NSW	198	88	44.4	65	32.8	45	22.7
Vic	197	85	43.1	87	44.2	25	12.7
Qld	452	182	40.3	153	33.8	117	25.9
SA	122	65	53.3	39	32.0	18	14.8
WA	155	44	28.4	58	37.4	53	34.2
Tas	43	23	53.5	10	23.3	10	23.3
NT	64	17	26.6	16	25.0	31	48.4
ACT	106	41	38.7	36	34.0	29	27.4
Australia	1,337	545	40.8	464	34.7	328	24.5

(a) Excludes SLAs where final ERP was zero.

As discussed in section 2.1, to include very small SLAs in the calculation of average errors for states/territories may result in misleading conclusions. For example, the SLA of Hume, a sparsely populated SLA on the outskirts of the Australian Capital Territory, had a preliminary 2001 estimate of 7 persons; however its final 1996 ERP was 14, and therefore the intercensal error for Hume was 50 per cent. Clearly, it would be meaningless to include such small SLAs in any analysis – such a high percentage error, caused by a very small population size, would be misleading for other areas included in the analysis. For this reason, SLAs with a final 2001 population less than 500, defined in this paper as 'very small' SLAs, are generally excluded in the calculation of average absolute percentage errors (the population residing in these 'very small' SLAs in 2001 was less than 0.1 per cent of the total Australian population). The paper also sometimes excludes SLAs with 2001 population less than 2,000, defined here as 'small' SLAs (the population residing in these 'small' SLAs in 2001 was less than 1.2 per cent of the total Australian population).

TABLE 8: AVERAGE ABSOLUTE INTERCENSAL ERROR, STATISTICAL LOCAL AREAS, 30 JUNE 2001(a)

	Number of SLAs(a)	*Average SLA size*	*Average absolute numeric error*	*Average absolute percentage error*	
				Excluding very small SLAs (ERP>500)	Excluding small SLAs (ERP>2000)
NSW	198	33,208	571	3.2	3.1
Vic	197	24,389	543	3.1	3.0
Qld	452	8,029	240	4.1	3.3
SA	122	12,391	203	2.4	2.1
WA	155	12,266	273	5.0	3.0
Tas	43	10,972	177	2.5	2.3
NT	64	3,090	210	7.2	6.7
ACT	106	3,012	112	3.8	3.2
Australia	1,337	14,518	321	3.8	3.2

(a) Excludes SLAs where final 2001 ERP was zero.

The average absolute error for SLAs in 2001, excluding very small SLAs, was 3.8 per cent (this reduced to 3.2 per cent when small SLAs were also removed). The average error was highest for the Northern Territory (7.2 per cent), and lowest for Tasmania (2.5 per cent).

Local Government Areas

SLAs conform to, or combine to form, Local Government Areas (LGAs). The analysis of population estimates for LGAs is especially important given that allocation of funds by governments depends somewhat on the distribution of LGA populations.

The LGA structure covers only *incorporated* areas of Australia. These are legally designated areas over which incorporated local governments have responsibility. The major areas of Australia not covered by incorporated bodies in 2001 were the northern parts of South Australia, most of the Northern Territory, and all of the Australian Capital Territory and the Other Territories.

In 2001, the LGA structure closely resembled the SLA structure in New South Wales and Western Australia and therefore for these states, the patterns observed with LGA population errors were similar to those errors associated with SLA population estimates.

TABLE 9: NUMBER AND AVERAGE SIZE OF LOCAL GOVERNMENT AREAS, 30 JUNE 2001

	Estimated Resident Population			*Local Government Areas*	
	Total	In unincorporated areas	*Per cent of ERP in unincorporated areas*	No.	Average ERP
NSW	6,575,217	1,220	*0.0*	174	37,782
Vic	4,804,726	91	*0.0*	78	61,598
Qld	3,628,946	—	—	125	29,032
SA	1,511,728	8,745	*0.6*	68	22,103
WA	1,901,159	—	—	142	13,388
Tas	471,795	—	—	29	16,269
NT	197,768	50,632	*25.6*	8	18,392
ACT	319,317	319,317	*100.0*	—	—
Australia	19,410,656	380,005	*2.0*	624	30,498

Nationally, and again in line with the under–estimate of the total Australian population, a larger number of LGAs were under–estimated (378 LGAs) than were over–estimated (246) in 2001. The trend for particular states/territories to have a majority of SLAs over– or under– estimated at the LGA level (table 10) resembles the trend at the SLA level (table 6) except for the Northern Territory where seven of the eight LGAs were over–estimated.

TABLE 10: DIRECTIONS OF INTERCENSAL ERRORS, LOCAL GOVERNMENT AREAS, 30 JUNE 2001

	Number of LGAs	*LGAs over–estimated*		*LGAs under–estimated*	
		No.	*%*	No.	*%*
NSW	174	37	21.3	137	78.7
Vic	78	28	35.9	50	64.1
Qld	125	50	40.0	75	60.0
SA	68	28	41.2	40	58.8
WA	142	81	57.0	61	43.0
Tas	29	15	51.7	14	48.3
NT	8	7	87.5	1	12.5
ACT	—	—	—	—	—
Australia	624	246	39.4	378	60.6

The average absolute percentage errors for LGAs (table 11) are similar to those for SLAs (table 8) for those states where the LGA structure closely resembles the SLA structure, ie. New South Wales and Western Australia, and also for South Australia.

TABLE 11: AVERAGE ABSOLUTE INTERCENSAL ERROR, LOCAL GOVERNMENT AREAS, 30 JUNE 2001

	Number of LGAs	*Average LGA size*	*Average absolute numeric error*	*Average absolute percentage error*	
				Excluding very small LGAs (ERP>500)	Excluding small LGAs (ERP>2000)
NSW	74	37,782	623	3.0	3.0
Vic	78	61,598	1,082	2.3	2.3
Qld	125	29,032	457	4.5	3.4
SA	68	22,103	301	2.3	2.1
WA	142	13,388	297	5.1	3.0
Tas	29	16,269	250	2.1	2.0
NT	8	18,392	522	11.7	8.2
Australia	624	30,498	519	3.6	2.9

There is a marked improvement in the errors once LGAs with populations under 2,000 are removed, especially in Western Australia (where the average error declined from 5.1 to 3.0 per cent), Queensland (from 4.5 to 3.4 per cent) and the Northern Territory (from 11.7 to 8.2 per cent). This again demonstrates how the size of percentage errors are especially dependent on the size of the population (discussed in section 2.1).

While for most states, the average percentage error for LGAs was smaller than for SLAs, there was an increase in Queensland (whose average SLA error was 4.0 per cent, compared with 4.5 per cent for LGAs). This anomaly is partly explained by a low average error of 3.4 per cent for the 282 SLAs that belong the 11 LGAs within Brisbane and surrounding urban areas, compared with an average error of 5.1 per cent for the remaining 163 SLAs – which align much more closely to LGAs[5].

Parts of state

Overall, capital city Statistical Divisions were over–estimated by around 61,400 persons, or +0.5 per cent. The population residing outside capital cities was under–estimated by 88,600, or –1.3 per cent.

TABLE 12: INTERCENSAL ERRORS, PART OF STATE, 30 JUNE 2001

	Capital city Statistical Division				*Balance of state/territory*			
	ERP ('000)		Difference		ERP ('000)		Difference	
	Preliminary	*Final*	*('000)*	*Per cent*	*Preliminary*	*Final*	*('000)*	*Per cent*
NSW	4,140.8	4,128.3	+12.5	+0.3	2,446.9	2,391.6	–55.3	–2.3
Vic	3,522.0	3,471.6	+50.3	+1.4	1,333.1	1,307.0	–26.1	–2.0
Qld	1,656.7	1,650.4	+6.3	+0.4	1,978.5	1,971.1	–7.4	–0.4
SA	1,100.1	1,108.0	–7.9	–0.7	403.7	402.3	–1.5	–0.4
WA	1,400.5	1,393.0	+7.5	+0.5	508.2	509.2	+1.1	+0.2
Tas	194.4	197.3	–2.9	–1.5	274.5	275.9	+1.4	+0.5
NT	107.4	106.8	+0.6	+0.5	90.9	90.2	–0.8	–0.8
ACT	313.9	318.9	–5.1	–1.6	0.4	0.3	–0.1	–16.1
Total	12,435.8	12,374.4	+61.4	+0.5	7,036.3	6,947.6	–88.6	–1.3

2.3 Comparing the 2001 estimates with earlier estimates

Table 13 compares the 2001 SLA and LGA intercensal errors with those for 1991 and 1996. Intercensal errors for 1996 are analysed in detail in ABS Demography Working Paper 98/1 *Issues in Estimating Small Area Populations* (ABS 1998).

[5] The 11 LGAs (containing 282 SLAs) within Brisbane and surrounding urban areas being: Brisbane (C), Caboolture (S), Caloundra (C), Gold Coast (C), Ipswich (C), Logan (C), Maroochy (S), Noosa (S), Pine Rivers (S), Redcliffe (C) and Redland (S). Queensland's remaining 163 SLAs are contained in 114 LGAs.

TABLE 13: AVERAGE ABSOLUTE INTERCENSAL ERRORS, SLAs & LGAs, 30 JUNE 1991, 1996 & 2001

	Statistical Local Areas						*Local Government Areas*					
	Excluding very small SLAs (ERP>500)			Excluding small SLAs (ERP>2000)			Excluding very small LGAs (ERP>500)			Excluding small LGAs (ERP>2000)		
	1991	*1996*	*2001*	*1991*	*1996*	*2001*	*1991*	*1996*	*2001*	*1991*	*1996*	*2001*
NSW	3.2	3.4	3.2	3.0	3.4	3.1	3.1	3.3	3.0	3.0	3.3	3.0
Vic	3.2	6.3	3.1	2.7	5.9	3.0	2.7	2.1	2.3	2.4	2.1	2.3
Qld	5.4	4.5	4.1	4.3	4.0	3.3	4.4	4.0	4.5	3.6	3.4	3.4
SA	3.0	2.7	2.4	2.4	2.0	2.1	2.8	2.6	2.3	2.2	2.0	2.1
WA	6.1	5.1	5.0	4.2	3.6	3.0	5.7	4.6	5.1	4.0	3.4	3.0
Tas	4.7	3.2	2.5	3.4	3.1	2.3	2.1	2.7	2.1	1.8	2.7	2.0
NT	5.3	7.9	7.2	4.6	6.6	6.7	6.3	5.8	11.7	4.8	5.9	8.2
ACT	4.0	3.9	3.8	3.0	3.3	3.2	–	–	–	–	–	–
Australia	4.4	4.6	3.8	3.5	4.1	3.2	3.5	3.4	3.6	2.9	3.0	2.9

For *SLAs* across Australia, the average absolute error declined between 1991 and 2001. The decline was more marked over the 1996 to 2001 period. The decline was similar whether very small SLAs, or small SLAs, were excluded. By state/territory:

excluding very small SLAs, the SLA estimates were, on average, the same or more accurate for all states/territories, excluding the Northern Territory, between 1991 and 2001; compared with 1996, the 2001 estimates were more accurate for all states/territories;

excluding small SLAs, the average 2001 estimates were less accurate than the 1991 estimates for New South Wales, Victoria, the Northern Territory and the Australian Capital Territory; between 1996 and 2001, the average error decreased for all states/territories except South Australia (marginally) and the Northern Territory (marginally).

At the *LGA* level, across Australia, the average absolute error has stayed relatively steady. Excluding very small LGAs, the average error increased marginally between 1991 and 2001 (after improving marginally between 1991 and 1996); excluding small LGAs, the average error was steady between 1991 and 2001 (improving marginally from 1996 to 2001). By state/territory:

excluding very small LGAs, the LGA estimates were, on average, the same or more accurate for all states/territories between 1991 and 2001, excluding Queensland (marginally less accurate) and the Northern Territory; compared with 1996, the 2001 estimates were more accurate for all states/territories, except Victoria, Queensland, Western Australia and the Northern Territory.

excluding small LGAs, the average 2001 estimates were less accurate than the 1991 estimates for Tasmania and the Northern Territory; between 1996 and 2001, the average error decreased for all states/territories except Victoria, South Australia (marginally) and the Northern Territory.

Table 7 shows that 75 per cent of the preliminary SLA estimates were estimated to within five per cent of their final estimates – this was an improvement on 1996 when 69 per cent of SLAs were estimated to within five per cent. At the LGA level, the percentage of preliminary estimates within five per cent of their final estimate was steady between 1996 and 2001, at 77 per cent.

The over–estimate of capital city Statistical Divisions in 2001 (a +0.5 per cent intercensal error) was in contrast to an under–estimate of capital cities in 1996 (–0.8 per cent); and vice–versa for rest of state Statistical Divisions – which were under–estimated by 1.3 per cent in 2001 and over–estimated by 1.1 per cent in 1996.

3 FACTORS AFFECTING ACCURACY

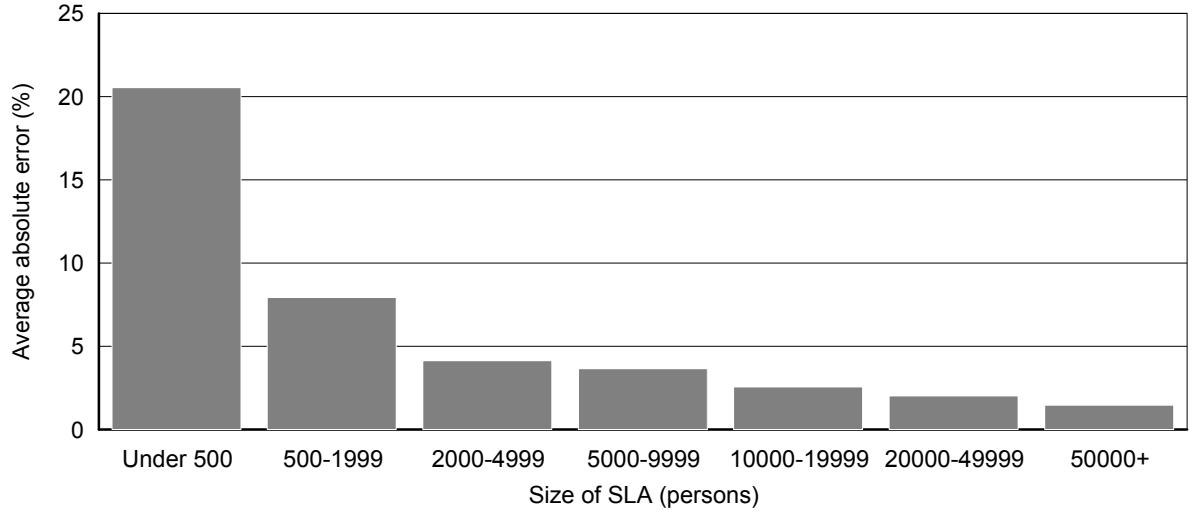
Several factors can influence the accuracy of a population estimate. It appears that some areas, by their nature, are more difficult to estimate accurately than others. This section categorises some underlying characteristics and factors of SLAs which potentially hinder the accuracy of population estimates, by assessing the 2001 intercensal errors for these SLAs.

3.1 Population size

Size of errors

As previously discussed, *larger populations tend to be more accurately estimated than small populations*, assuming the measure of accuracy is the percentage error. Table 2 indicates the range of SLA size by state/territory. Note that larger SLAs tend to lie in urban areas.

FIGURE 1: AVERAGE ABSOLUTE INTERCENSAL ERROR IN 2001, STATISTICAL LOCAL AREAS, BY SIZE OF STATISTICAL LOCAL AREA 30 JUNE 2001



As the size of an SLA population increased, there was a steady overall decline in the estimate's percentage error. The average absolute error for SLAs with populations of less than 500 was 20 per cent; but for SLAs with populations of 50,000 or more, the average error was only 1.5 per cent – and none of these SLAs had discrepancies more than five per cent.

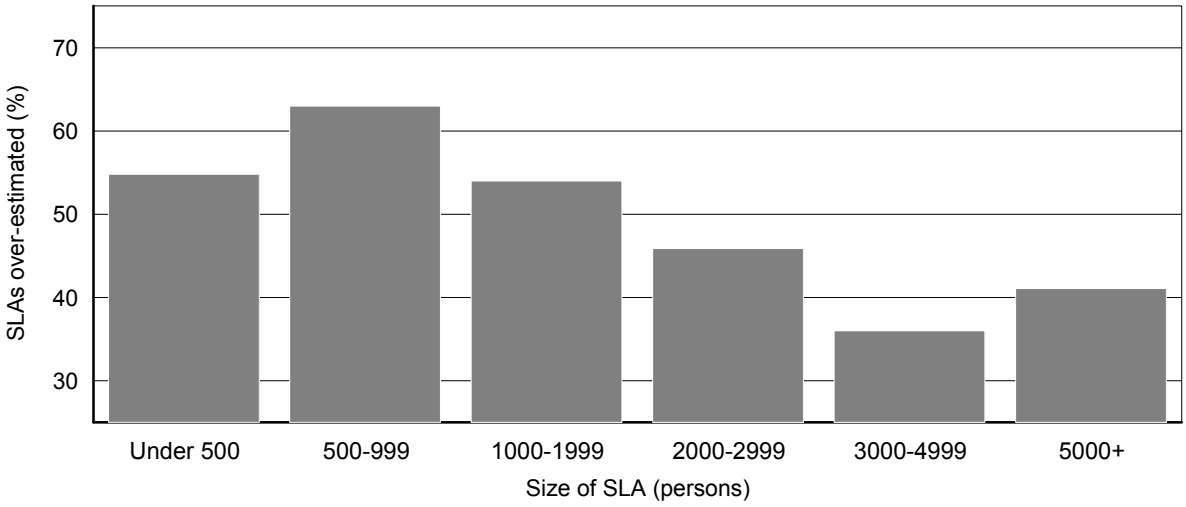
Although the average error for very small SLAs is relatively high, the average error of 20 per cent observed in 2001 is lower than in 1996 (24 per cent). There was a similar improvement in the errors of SLAs with 50,000 or more persons – the average error of 1.5 per cent in 2001 was lower than the 2.0 per cent observed in 1996.

No SLAs with a population of 50,000 or more had an error greater than five per cent in 2001; in 1996, 10 per cent of such SLAs had an error greater than five per cent.

Direction of errors

Another feature regarding population size is that *the populations of small regions are more likely to be over–estimated than the populations of larger regions*. Of the SLAs with less than 2,000 persons, 56 per cent were over–estimated. However, of the SLAs with a population of 2,000 or more, only 41 per cent were over–estimated.

FIGURE 2: PERCENTAGE OF STATISTICAL LOCAL AREAS OVER–ESTIMATED IN 2001, BY SIZE OF STATISTICAL LOCAL AREA 30 JUNE 2001



3.2 Population growth

It is useful to get an idea of the distribution of SLAs where the ERP declined or grew, and the extent of the decline/growth, between 1996 and 2001.

TABLE 14: DISTRIBUTION OF STATISTICAL LOCAL AREAS, BY POPULATION GROWTH 1996–2001

	Change in Estimated Resident Population, 1996 to 2001									
Number of SLAs	*Below –10%*	*–10 to <–5%*	*–5 to <0%*	*0 to <5%*	*5 to <10%*	*10 to <20%*	*20 to <50%*	*50% & over*	**Total number of SLAs**	*State/ territory 1996–2001 change (%)*
NSW	2	6	59	59	36	31	3	2	**198**	*6.0*
Vic	3	13	44	69	29	28	9	3	**198**	*5.4*
Qld	13	22	70	123	81	69	54	20	**452**	*8.7*
SA	7	9	31	44	20	9	2	0	**122**	*2.5*
WA	27	14	24	30	19	20	20	1	**155**	*7.7*
Tas	1	8	17	12	3	2	0	0	**43**	*–0.6*
NT	4	10	13	10	4	11	8	4	**64**	*8.8*
ACT	8	16	41	18	5	7	5	6	**106**	*3.6*
Australia	65	98	299	365	197	177	101	36	**1,338**	*6.0*

(a) Excludes SLAs with 1996 and 2001 ERP = 0; SLAs which increased from a zero population in 199 6 (this increase is mathematically undefined) are categorised as having 50%+ increase.

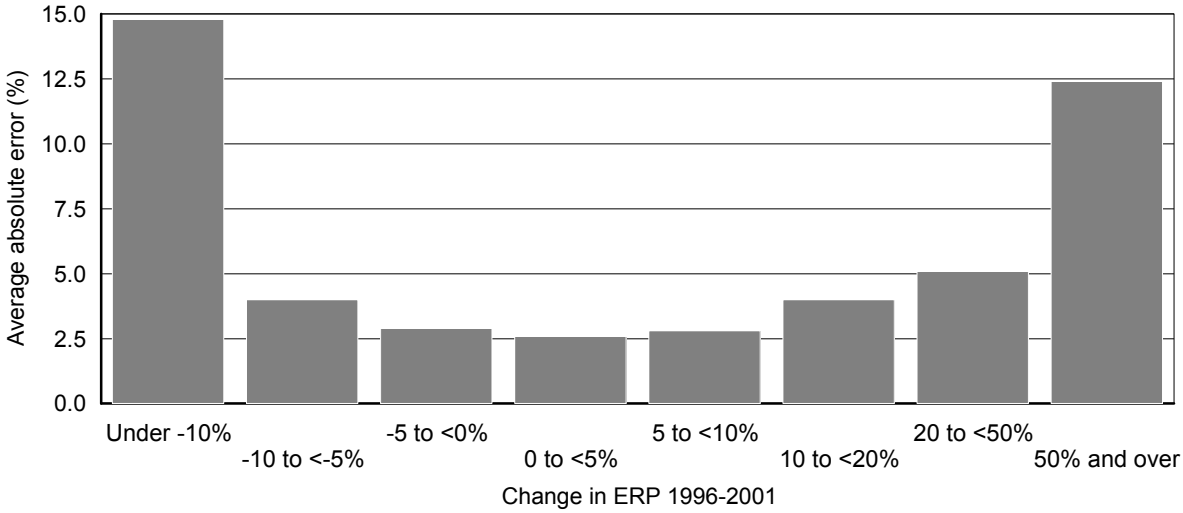
Size of errors

Moderately growing populations are estimated more accurately than rapidly growing or declining populations.

The estimates for SLA populations that had declined by more than 10 per cent from 1996 to 2001 had an average absolute intercensal error of 14.8 per cent. For populations that grew by 20 per cent or more, the average error was 7 per cent. Yet the average error for populations that grew, but by less than 10 per cent, was only 2.6 per cent.

The accuracy of estimates for growing SLAs improved from 1996 to 2001 . For SLAs which increased by more than five per cent over the previous five years, the average error (excluding very small SLAs) declined from 5.7 to 4.3 per cent. The improvement was similar for SLAs which grew by more than ten percent – from 6.7 down to 5.2 per cent.

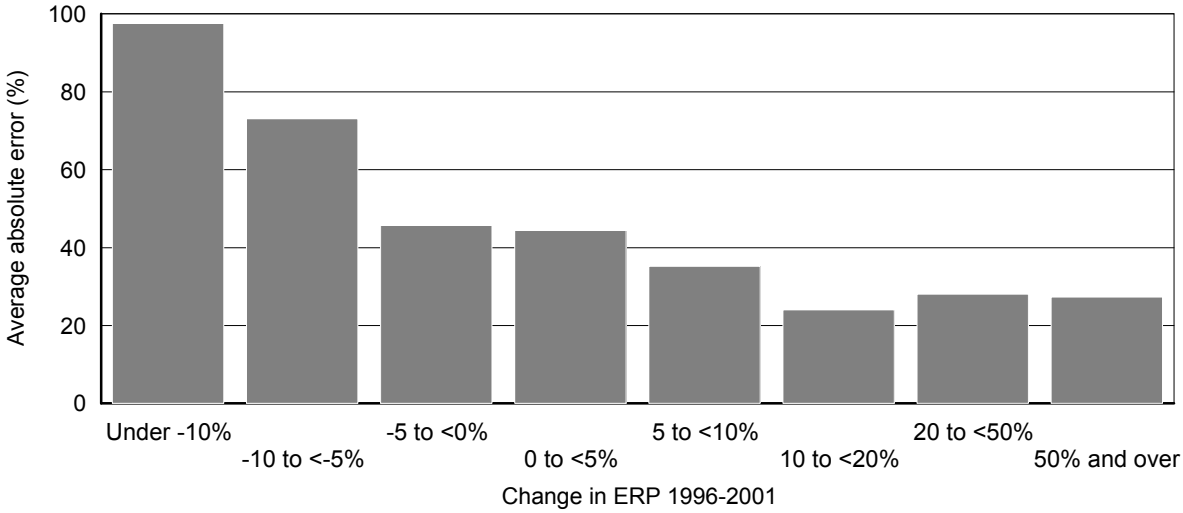
FIGURE 3: AVERAGE ABSOLUTE INTERCENSAL ERROR IN 2001, STATISTICAL LOCAL AREAS, BY POPULATION CHANGE 1996–2001



Direction of errors

Regions with declining populations are much more likely to be over–estimated than those that grew rapidly. Almost 98 per cent of the SLAs which lost more than 10 per cent of their population between 1996 and 2001 were over–estimated. However only 28 per cent of the SLAs that grew by 20 per cent or more were over–estimated.

FIGURE 4: PERCENTAGE OF STATISTICAL LOCAL AREAS OVER–ESTIMATED IN 2001, BY POPULATION GROWTH 1996–2001



When preparing the preliminary 2001 estimates, there were many SLAs, in hindsight, where it would have been more accurate to assume no change whatsoever, rather than attempting to estimate change over the five years. Overall, in 29 per cent of SLAs, the difference between the 1996 ERP and the final 2001 ERP was smaller than the observed intercensal error; in other words, for these SLAs it would have been better to keep the 1996 ERP constant until 2001, rather than deriving a particular preliminary 2001 estimate.

It was more likely that a constant ERP produced a more accurate 2001 figure for smaller SLAs: for 36 per cent of SLAs with a population under 500, it would have been more accurate to use the 1996 estimate rather than preliminary 2001 estimate; however in just 21 per cent of SLAs with a population of 10,000 or more, it would have been more accurate to use the 1996 estimate rather than preliminary 2001 estimate.

It is still necessary to estimate the populations of all SLAs of course, as we do not have the advantage of hindsight of which SLAs would have best been held constant at the time of estimation. However the trend observed in 2001 implies that it may be safer to adopt a more conservative approach, such as keeping ERP constant, when estimating smaller populations.

3.3 Changes in boundaries

Most states/territories had SLAs in 2001 which were part of different areas, or did not exist, in 1996. South Australia, for instance, had wholesale LGA restructuring affecting almost the entire state in the 1998 ASGC; this in turn led to major SLA boundary changes.

When an adjustment is made to an SLA boundary, the ERP based on the new boundary must be calculated as at the previous census year (rebased), to establish a consistent time series on the new boundaries. It is essential to obtain good quality estimates of the previous census year's SLA populations; this relies on accurate information about the boundary changes and the distribution of dwellings and population to the new areas.

The accuracy of the rebased 1996 population estimates depends, to a great extent, on the alignment of the new SLA boundaries to the 1996 Census Collection District (CD) boundaries (the CD is the base for collection and dissemination of census data).

In 2001, the errors for SLAs involved in boundary changes were, overall, similar to the errors for all SLAs. There were approximately 160 SLAs in 2001 which did not exist with the same boundary in 1996 and where the change in boundary involved population change (excluding amalgamations of whole SLAs). The average intercensal error for these SLAs was 3.8 per cent – the same as for all SLAs.

A massive realignment of SLA boundaries in Victoria between 1994 and 1996 – where new SLA boundaries often did not align with 1991 CD boundaries – led to many large intercensal errors for Victorian SLAs in 1996; the average absolute error for Victorian SLAs in 1996 which underwent a boundary change since 1991 was 7.1 per cent. However for South Australia, where there was a similar extent of boundary changes in 1998 (about half of South Australian SLAs in 2001 did not exist with the same boundaries in 1996), the average absolute error for those SLAs involved in a boundary change was a low 2.0 per cent. The difference between these rounds of boundary changes was that the South Australian changes of 1998 were much less complicated than the Victorian changes of 1994–1996, and aligned well with 1996 Census CD boundaries (again, unlike the Victorian changes).

For Victoria, the absence of such a large and complicated boundary reshuffle since 1996 was the main reason behind a large drop in Victoria's average SLA intercensal error – from 6.3 per cent in 1996 to 3.1 per cent in 2001.

3.4 Quality of input data

The quality of a preliminary population estimate is highly dependent on the quality of the population indicator data. For indicator data to be utilised in an estimation model, it must satisfy several criteria:

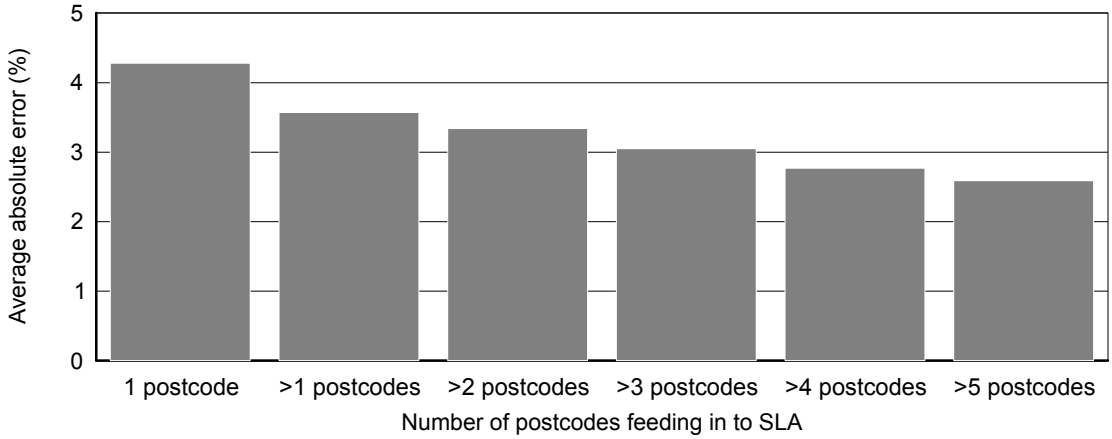
Indicative ability: The fundamental aspect of population indicator data is that it must indicate how the total population changes over time.

Historical availability: To confidently establish the relationship between the indicator data and population, the indicator data must have been available for an appropriate number of years. Additionally, the data must be reasonably consistent over this time frame. Ideally the data is consistent in terms of scope, definition and collection procedure over

the entire period when the relationship was being established (the modelling phase), and when the population is being estimated (the estimation phase).

Geographic availability: For SLA population estimates, the indicator data should be available at the SLA level. However several potentially useful data sources, for example Medicare enrolments, are available at the postcode rather than SLA level. This data must be converted to SLAs. The quality of this conversion depends on the relationship (concordance) between postcodes and SLAs, which varies across regions. Overall, the higher the number of postcodes feeding in to an SLA, the lower the average error (figure 5). For SLAs with only one postcode feeding in to it, the average error was 4.3 per cent; however for SLAs with more than three postcodes feeding in, the average error was 3.0 per cent. This may imply that errors in the postcode to SLA concordance tend to cancel each other out for SLAs with several postcodes feeding in to it; while for SLAs stemming from just one postcode, it is especially critical to determine the correct concordance.

FIGURE 5: ABSOLUTE AVERAGE INTERCENSAL ERROR IN 2001, STATISTICAL LOCAL AREA, BY NUMBER OF POSTCODES FEEDING IN TO SLA



Changes in SLA boundaries can also have an impact on the indicator data, especially when recalculating the historical indicator data on the new boundaries.

Additionally, to produce timely population estimates, the indicator data must be available very soon after the reference period for which the population estimate is required.

3.5 State/territory totals

The preliminary SLA population estimates used in this analysis were constrained to preliminary state/territory totals. The final SLA estimates were constrained to final state/territory totals. Table 6 shows that there was a variation of between –1.6 per cent (ACT) and +0.5 per cent (Victoria) between preliminary and final state/territory ERPs.

It may be more appropriate then to think of an SLA population in terms of its *share* of the state/territory population, rather than its number of persons. This is especially relevant when funding, resources etc are allocated on a share of state's population basis. In determining the accuracy of the ERPs, one way to deal with this is to apportion the revision made to the state/territory population across all SLAs in that state/territory on a pro–rata basis; for example, given that Victoria was over–estimated by 0.5 per cent, adjust each SLA ERP in Victoria downwards by 0.5 per cent, and compare these adjusted preliminary ERPs with the final data.

Table 15 shows that pro–rating changes to final state/territory totals across SLAs made minimal differences to the average SLA or LGA intercensal errors. The biggest difference was for NSW: reflecting the relatively large error of –0.65 per cent for the state, the average absolute error for both SLAs and LGAs within NSW decreased by 0.3 percentage points.

TABLE 15: INTERCENSAL ERRORS, ADJUSTING FOR STATE/TERRITORY ERRORS, 30 JUNE 2001

	Intercensal error – state/territory total(a)		*Average absolute intercensal error – Statistical Local Areas(b)*		*Average absolute intercensal error – Local Govt Areas(b)*	
	Number ('000)	Per cent	Unadjusted (per cent)	Adjusted to final state/terr.ERP(%)	Unadjusted (per cent)	Adjusted to final state/terr.ERP(%)
NSW	–42.8	–0.65	3.2	2.9	3.0	2.7
Vic	+24.2	+0.50	3.1	3.2	2.3	2.4
Qld	–1.1	–0.03	4.1	4.1	4.5	4.5
SA	–9.3	–0.62	2.4	2.4	2.3	2.2
WA	+8.6	+0.45	5.0	5.0	5.1	5.0
Tas	–1.5	–0.32	2.5	2.5	2.1	2.1
NT	–0.2	–0.09	7.2	7.2	11.7	11.7
ACT	–5.1	–1.61	3.8	4.0	–	–
Australia	–26.6	–0.14	3.8	3.8	3.6	3.5

(a) Based on projected overseas migration data.
(b) Excluding SLAs/LGAs with 2001 ERP less than 500.

3.6 Summary

Table 16 presents the average absolute intercensal errors in 2001 when SLAs with particular characteristics are excluded, by state/territory.

TABLE 16: AVERAGE ABSOLUTE INTERCENSAL ERROR, STATISTICAL LOCAL AREAS, 30 JUNE 2001

	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Australia
AVERAGE ABSOLUTE INTERCENSAL ERROR (%)									
Category									
Excluding very small SLAs(a)	**3.2**	**3.1**	**4.1**	**2.4**	**5.0**	**2.5**	**7.2**	**3.8**	**3.8**
Excluding small SLAs(b)	3.1	3.0	3.3	2.1	3.0	2.3	6.7	3.2	3.2
Excluding very small SLAs and:									
– rapidly decreasing SLAs(c)	3.2	3.0	3.7	2.3	3.7	2.5	6.6	3.3	3.4
– rapidly increasing SLAs(d)	2.9	2.5	3.7	2.2	5.5	2.4	5.8	3.2	3.4
– rapidly decreasing or increasing SLAs	2.9	2.4	3.1	2.0	3.7	2.4	4.8	2.6	2.9
– SLAs that incurred boundary changes(e)	3.2	2.7	4.0	2.8	5.1	2.5	6.7	3.8	3.8
– SLAs forced to final state/territory total	2.9	3.2	4.1	2.4	5.0	2.5	7.2	4.0	3.8
NUMBER OF STATISTICAL LOCAL AREAS									
All SLAs(f)	199	200	454	125	156	44	65	107	1,350
Excluding very small SLAs(a)	195	196	438	117	141	41	61	86	1,275
Excluding small SLAs(b)	187	194	384	104	83	35	47	74	1,108
Excluding very small SLAs and:									
– rapidly decreasing SLAs(c)	193	194	428	115	121	40	58	84	1,233
– rapidly increasing SLAs(d)	160	157	298	106	101	40	39	74	975
– rapidly decreasing or increasing SLAs	158	155	288	104	81	39	36	72	933
– SLAs that incurred boundary changes(e)	172	169	396	63	130	41	57	86	1,114

(a) Very small SLAs are those with 2001 ERP less than 500.
(b) Small SLAs are those with 2001 ERP less than 2000.
(c) Rapidly declining SLAs are those that declined by greater than 10 per cent between 1996 and 2001.
(d) Rapidly increasing SLAs are those that increased by more than 10 per cent between 1996 and 2001.
(e) SLAs that incurred boundary changes are those that incurred changes in both area and population between 1996 and 2001, excluding amalgamations of whole SLAs.
(f) excluding Other Territories.

Table 16 indicates particular aspects which influenced the accuracy of estimates for each state/territory. For instance, the table implies that a major reason for the relatively high average error for Western Australia is the relatively large number of small SLAs (ie. those SLAs ranging in size from 500 to 2,000 persons) – the average error declined from 5.0 per cent to 3.0 per cent when these SLAs are removed from the calculation of the average (there were about 58 SLAs which fell into this category: 141 SLAs above 500 persons minus 83 SLAs above 2,000 persons). Similarly, the existence of many SLAs with rapidly changing populations in Queensland, Northern Territory and Australian Capital Territory appears to be part reason for large intercensal SLA errors in these states/territories.

4 SUMMARY AND CONCLUSION

Population estimates at the Statistical Local Area (SLA) level are prepared annually by the Australian Bureau of Statistics. The accuracy of these estimates can be gauged each time the five–yearly Population Census is held (assuming the census data is of good quality) by assessing the intercensal errors. Although there is no overriding criteria to judge the accuracy of a set of small area population estimates, Australia's small area population estimates appear to be reasonable, although there is always room for improvement. In 2001, just over 75 per cent of Australia's SLAs were estimated to within five per cent of their 'true' value. The average absolute intercensal SLA error in 2001 was 3.8 per cent, well down on the 1996 average (4.6 per cent).

A number of broad factors influence the degree of accuracy by which the populations of small areas can be estimated. Estimates tend to be less accurate for areas with very small populations, extreme population decline or growth, and limited availability of high quality population indicator data. Other influences, such as boundary changes, are also potentially obstructive; however the quality of estimates for these areas can still be reasonably good if sensible boundary changes are made.

Because of these factors, detailed analysis of intercensal error, such as that documented in this paper, is a crucial component of the estimation process. Such analysis provides a valuable insight into the overall accuracy of small area population estimates, especially for particular types of areas, and assists in the identification and further investigation of problematic areas.

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