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Indigenous mortality estimation: an application of Bhat's recent reformulation of Brass Growth Balance Equation

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Abstract

For populations where death registrations are deficient and population estimates are of reasonable quality, some plausible estimates of mortality can be derived. Brass Growth Balance Equation (Brass, 1975) opened the way to the development of the techniques of mortality measurement with incomplete data. The Brass technique estimated a 'consistency' factor between the population estimates at the two census dates and registered intercensal deaths using the stable population theory and used this consistency factor, assumed invariant by age, as the basis for adjusting the registered deaths (or more correctly, the observed age-specific death rates), and then calculating the conventional measures of mortality such as a life table. Over time, the original equation was modified, mainly in terms of softening of the stability of the population assumption. However, another assumption remained, namely the application of the technique to the closed population (for migration) only. Bhat (2002) modified the Brass Growth Balance Equation by a 'migration' term and thus lifted the last restriction of the closed population for the application of the technique.

This paper applies Bhat's modification to the Brass Growth Equation to measure Indigenous mortality. Specifically, the changed identification of Indigenous population between the two adjacent census enumerations, termed as 'identification migration' or 'non-biological growth' (growth which is unexplainable by demographic factors) of the Indigenous population, is allowed as the migration component in Bhat's modification. The paper calculates the consistency of Indigenous death registrations for the 1991-1996 and 1996-2001 intercensal periods relative to population estimates at the beginning and end of each five-yearly period. A consistency factor, assumed constant for each age group, is applied to the observed age-specific death rates which are then used for the calculation of the Indigenous life tables. The paper assesses the sensitivity of the results to assumptions about the level and age distribution of non-biological growth of the Indigenous population. The sensitivity analysis is restricted to the 1996-2001 period. Results obtained from the sensitivity analysis show that life expectancy estimates derived under various assumptions vary across the states/territories and Australia, and a subjective decision on the life expectancy at birth estimates is necessary for any useable life tables for further analytical work, eg. backward or forward population projections of the Indigenous population.

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Australian Government Department of Immigration and Multicultural and Indigenous Affairs

Indigenous mortality estimation: an application of Bhat's recent reformulation of Brass Growth Balance Equation*

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Abstract

For populations where death registrations are deficient and population estimates are of reasonable quality, some plausible estimates of mortality can be derived. Brass Growth Balance Equation and its recent modification by Bhat are used in this paper to measure Indigenous mortality. Specifically, the changed identification of Indigenous population between the two consecutive census enumerations, termed as 'identification migration' or 'non-biological growth' (growth which is unexplainable by demographic factors) of the Indigenous population, is allowed as the migration component in Bhat's modification. The paper calculates the consistency of Indigenous death registrations for 1996-2001 intercensal period relative to population estimates at the beginning and end of the five-yearly period. A consistency factor, assumed constant for each age group, is applied to the observed age-specific death rates which are then used for the calculation of the Indigenous life tables.

The paper assesses sensitivity of the results to assumptions about the level and age distribution of non-biological growth of the Indigenous population. Results obtained show that life expectancy estimates derived under various assumptions vary across the states/territories and Australia, and a subjective decision on the life expectancy at birth estimates is necessary for any useable life tables for further analytical work, eg. backward or forward population projections of the Indigenous population.

Introduction

The calculation of the death rate requires perfect data on deaths that occur in a period (usually a year) and an estimate of the population exposed to those deaths at the mid-point of the period. The rates can be made specific by age and sex and life tables can be calculated. In the case of the Indigenous mortality estimation, the situation is far from being perfect. Both the Indigenous death registrations and population estimates have limitations.

Indigenous identification remains the main hurdle in getting accurate account of deaths and population data for the Indigenous population of Australia. While there is complete coverage of death registrations for the total population of Australia, the numbers of deaths for the Indigenous population that are identified in the registration data remain seriously deficient. Also, while official census year estimates of the Indigenous population are considered to be accurate for the time, comparisons of successive census year population estimates reveal larger intercensal increase in population which is not demographically consistent with the first census date population estimates. The increases in population size observed between the 1996 and 2001 censuses can not be explained by demographic events (namely births and deaths occurring during the intercensal period). In fact the intercensal increase suggests that the population has grown as if there had been migration gains from overseas. As this has not occurred the main factor explaining the increase has been thought to be 'identification migration'. This essentially means that more people have identified themselves as being of Indigenous origin when enumerated in more recent census than when they were enumerated at a previous census.

Demographers have provided several alternative methods which combine defective death registrations and reasonably good population estimates both by age and sex to determine the undercoverage factor by which registered deaths are adjusted to provide plausible measures of mortality, including the life table. There are assumptions to be made in the application of these methods. The major assumption is that the population being studied is stable, ie a population which is constant in its proportionate age structure over time and is closed to migration. The other assumption is that the undercoverage factor of registered deaths is invariant by age. Divergence from the stability assumption has been tested in many applications and the techniques developed have been found to be robust to the violation of this assumption. A review of the techniques is given by Gray (1986).

Given the coverage limitations of Indigenous death registrations and mismatch of Indigenous population estimates due to Indigenous identification migration, the Australian Bureau of Statistics (ABS) used the Preston and Hill (1980) method to adjust for the undercoverage of death registrations during 1991-96 (ABS: 1998a, 1998b). The application of the Preston and Hill method requires an assumption that the population during the intercensal period remains closed to migration. The Indigenous identification, as mentioned above, has been quite large and for this reason the Indigenous population cannot be considered as closed to migration. In retrospect, the Preston and Hill method was inappropriately applied for the Indigenous mortality estimation.

This paper describes a different method for adjusting the observed age-specific death rates. It uses the Brass Growth balance Equation (Brass, 1975) and its recent reformulation by Bhat (2002). The main advantage of Bhat method is that it allows for the migration component to be introduced into the Brass Growth Balance Equation. Identification migration is regarded as the migration component in Bhat method. The paper evaluates the outcomes of using the method for the 1996-2001 period at the state/territory level and for both males and females. The paper also assesses the sensitivity of the method to assumptions about the level of identification migration and its age distribution.

The technique

Brass Growth Balance Equation (Brass, 1975) was the first innovation which gave a method of 'balancing' population growth and death registrations during an intercensal period using the stable population theory and deriving an adjustment factor for the under registration of deaths. The method requires population data classified by age and sex and the age distribution of the registered deaths by age and sex. The method was modified over time, mainly in terms of its application to non-stable populations. Until recently, the newly developed methods were applied to the closed populations, ie to population not exposed to migration. A recent paper by Bhat (2002) lifted this restriction and introduced interstate migration to study mortality differentials across the States in India.

The balancing equation is defined as

$$P2 = P1 + B - D + NM$$

Where P2 is the population at the second census, P1 is the population at the first census, B is births, D is deaths, and NM is net migration. All the population components are for the intercensal period.

This equation can be written as

$$B = P2 - P1 + D - NM$$

$$B = \text{Growth of population} + D - NM,$$

where P2 - P1 is the growth of the population in the intercensal period.

In the original formulation of Brass, the net migration was not allowed and the above equation was converted to rates (instead of the numbers) above age a. Using the stable population theory, Brass defined:

$N(a)/N(a+) = r + D(a+) / N(a+)$

where N(a) is the number of persons of exact age a; N(a+) is the total number of persons aged a and over, D(a+) is the total number of deaths occurring to persons aged a and over; and r is the growth rate. Brass proved that this equation is exact for stable, closed population. According to Brass, N(a) may be thought as being the number of persons in a year entering the group of those aged a and over, the ratio N(a)/N(a+) can be interpreted as a 'birth rate' for the population aged a and over. D(a+)/N(a+) is the death rate corresponding to the same population; and if one denotes by r(a+) the growth rate for the population aged a and over, the equation becomes

$N(a)/N(a+) = r(a+) + D(a+) / N(a+)$

If the registered number of deaths is D*(a+) and is equal to C(a) D(a+), where C(a) is the correction factor for deaths at age a+, the equation becomes

$N(a)/N(a+) = r(a+) + (1/C(a)) (D^*(a+) / N(a+))$

If C(a) is same for all a's, it can be replaced by C. Also in a stable population r(+) = r (ie it is the same for all a's). Assuming 1/C = K the equation becomes

$N(a)/N(a+) = r + K (D^*(a+) / N(a+))$

This is a linear equation like Y = A+BX, where A (=r) is the intercept and B (=K) is the slope of the line.

Fitting the line with the observed data can determine r (rate of growth of the population) and K (=1/C), the factor to adjust the registered deaths. (United Nations, 1983, pp.139-140).

Having determined a plausible value of K, the registered deaths are adjusted and the mortality indicators are calculated. Different ways of fitting the straight line (least square, orthogonal regression, group mean method etc) give different values of r and K, but these fluctuate in a narrow range generally. Bhat has advocated the use of the orthogonal regression method in his paper (Bhat, 2002) although an average based on these methods would be as good.

In the later developments of the Brass growth balance method, populations at two end points (5 or 10 years apart) have been used and the 'Y' component of the linear equation is modified to take into account some differentials in growth and migration rates above age a.

In Bhat's formulation, the above equation becomes,

$[b(a+) - u(a+) + v(a+)] = n + (1/C)\,(d^*(a+))$

where b(a+) is the 'partial' birth rate, u(a+) is the 'partial growth differential', v(a+) is the 'partial migration differential', and d*(a+) is the 'partial' death rate in the population aged a and over. n is the natural increase rate and C is the coverage of the registered deaths. The rationale behind the technique is as follows:

The growth rate of a population aged a and over in a closed population can be expressed as

$$r(a+) = b(a+) - d(a+) \qquad (1)$$

Equation (1) can be generalised to any population

$$r(a+) = b(a+) - d(a+) + m(a+) \qquad (2)$$

where m(a+) is the 'partial' net migration rate for a population aged a and over.

Let the 'partial growth differential' of the population aged a and over be

$$u(a+) = r(a+) - r(0+)$$

$$\text{or, } r(a+) = u(a+) + r \qquad (3)$$

where r is the growth rate of total population (same as r(0+)).

Similarly, let the 'partial migration differential' of the population aged a and over be

$$v(a+) = m(a+) - m(0+)$$

$$\text{or, } m(a+) = v(a+) + m \qquad (4)$$

where m is the migration rate of total population (same as m(0+)).

Equation (2) can now be rewritten as,

$$b(a+) - u(a+) + v(a+) = r - m + d(a+) \quad (5)$$

By assuming that the level of under-reporting of deaths is constant by age, equation (5) becomes

$$[\, b(a+) - u(a+) + v(a+)] = n + 1/C \; d^*(a+) \quad (6)$$

where $d(a+) = d^*(a+)/C$

which is the partial death rate at ages a and over calculated from the reported deaths.

n is the rate of natural increase of the population.

Equation (6) is identical to fitting a line Y = A + BX, where A(=n) and B(=1/C) are as defined earlier.

For equation (6) all the input data are calculated from the population by age and sex at two points of time (5 or 10 years apart), and age and sex data of registered deaths, and migration in the intervening period.

In this paper, the 1/C factor based on registered deaths at all ages 5 to 69 is assumed to apply to deaths at all ages. The method restricts the inclusion of the 0-4 age group. The age group 70-74 is also recommended for exclusion and this has been accepted.

The data

The data needed for applying Bhat method are: (i) population estimates at the beginning and end of the five year period (rather than actual census counts, 30 June population estimates based on the respective census counts have been used), (ii) intercensal deaths, and (iii) the level and a proportionate age distribution of identification migration. All data are required by five year age groups, sex and state and territory.

To gauge the magnitude of data, the population totals for 1991, 1996 and 2001 and the registered deaths during intercensal periods 1991-96 and 1996-2001 are given in Table 1. The level and the proportionate age distribution of identification migration remain unknown. An approximation of these is provided later in the paper.

Table 1 :Indigenous population estimates (ERP) and registered intercensal deaths, 1991 to 2001

	Sex	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Aust(a)
1991 ERP										
	Males	37821	8976	37297	8643	22343	4840	21997	805	142826
	Females	37199	8914	36917	8596	21839	4621	21757	811	140734
	Persons	75020	17890	74214	17239	44182	9461	43754	1616	283560
1996 ERP										
	Males	54103	11149	51525	10810	27794	7620	25836	1522	190468
	Females	55822	11449	53292	11241	28411	7702	26040	1536	195581
	Persons	109925	22598	104817	22051	56205	15322	51876	3058	386049
2001 ERP										
	Males	67432	13799	61526	12604	32881	8718	28492	1963	227526
	Females	67456	14047	64384	12940	33050	8666	28383	1946	230994
	Persons	134888	27846	125910	25544	65931	17384	56875	3909	458520
1991-96 Deaths										
	Males	592	150	58	323	1079	11	1092	16	3323
	Females	422	113	43	257	799	7	852	13	2508
	Persons	1014	263	101	580	1878	18	1944	29	5831
1996-2001 Deaths										
	Males	1007	306	1498	389	1093	30	1155	12	5490
	Females	730	210	1151	263	751	26	917	8	4056
	Persons	1737	516	2649	652	1844	56	2072	20	9546

(a) includes Other territories.

The percentage age distribution of the Indigenous estimated resident population at 30 June 1991 and 2001, based on respective censuses, has remained more or less the same. The index of dissimilarity (U.S Bureau of Census, 1973, p. 179) shows quite low values in comparison to its theoretical range of 0 to 100. The observed values fall around 5 or below 5 except for the ACT, where the Index value could be unreliable due to small numbers of the Indigenous population (Table 2). Stability of the age distribution of the population, as required in Bhat procedure, is therefore not much of an issue for the Indigenous population.

Table 2 :Index of dissimilarity (a) between the age distributions, 1991-1996, and 1996-2001

Period	Sex	NSW	VIC	Qld	SA	WA	Tas	NT	ACT	Aust
1991-96	Males	4.6	5.1	3.6	4.3	4.9	5.1	2.8	6.1	3.7
	Females	3.5	3.7	2.9	3.0	4.3	4.6	3.7	4.4	2.9
1996-01	Males	3.6	4.2	3.4	4.6	3.9	4.3	3.6	8.8	3.2
	Females	4.2	4.0	2.9	4.6	3.6	4.3	3.7	4.9	3.2

(a) It is one-half of the sum of the absolute differences in the two percentage age distributions.

In regard to the quality of the Indigenous deaths data some observations may be made by simply looking at the annual series of counts available for each state and territory (ABS, 2002, p. 78). The series look fairly sensible for South Australia, Western Australia and the Northern Territory for the entire period since 1991. The year to year counts are consistently much the same in number and appear to stand at a reasonable level. However, in the other jurisdictions, especially New South Wales and Queensland, the data for the first half of the 1990s are clearly incomplete. They show that relatively few, if any, Indigenous deaths were recognised. Since about 1996/97 the counts in these states have begun to look more reasonable and more consistent on a year to year basis as well.

Level and age distribution of 'identification migration'

There are no data available on either the level or the age distribution of 'identification migration'. These must be estimated. A two prong approach is used in this paper. First, the level of 'identification migration' is estimated as the difference between the observed intercensal annual growth rate and an assumed growth rate of the population. Alternative levels of assumed growth rates will yield different levels of 'identification migration', on the assumption that there is no international migration of Indigenous people and their interstate migration can also be ignored. Assumed growth rate is therefore a natural increase rate only. As the observed population growth rate varies across the states (and Australia) several levels of 'identification migration' result.

The age distribution of 'identification migration' is estimated by forward survival of the earlier census year 30 June population estimate to the next census year 30 June estimate, and taking the difference between the second census date population estimate and the forward survived population estimate for the same date. The calculations are done separately for males and females and for five-year age groups of population. For these calculations two elements are required: (i) the fertility rates, and (ii) the life table survivorship ratios, both applicable to the intercensal period under investigation. As both of these are unknown, the children aged 0-4 in the survived population is estimated by the child women ratio (state-specific) calculated from the second census date population estimates. The life table survivorship ratios are taken from the adjusted life tables (for Australia only) based on observed age-specific death rates and an application of Bhat methodology assuming no 'identification migration'. The proportionate age distribution of 'identification migration' is examined for various states (and Australia) for two time periods 1991-96 and 1996-2001. As expected there is considerable variation in the age distribution of 'identification migration' across the states but it is clear that this migration is mostly concentrated at the younger ages (see Table 3).

It can be hypothesised that children of mixed marriages and/or non-Indigenous children may have been specified as Indigenous in census enumeration by person filling the census form, but this can not be validated. In addition, the derived age distributions of 'identification migration' are a residue difference between the census date population estimate and the survived population estimate from the last census. Any differential misstatement of age in the two census counts (which forms the basis of ERP) will also contribute to the accuracy of the age distribution of 'identification migration'.

In addition to two main age distributions of 'identification migration' for 1991-96 and 1996-2001 for Australia, we have selected two more age distributions, 2001 Census date ERP and 1996-2001 'identification migration' for South Australia for sensitivity analysis. The 1991-96 age distribution of 'identification migration' was estimated using the life tables for Australia for 1991-96 (calculated using Bhat adjustment) and the child-women ratio for Australia from the 1996 Indigenous population estimates.

Table 3: Age distribution of 'identification migration'

	1991-96 (a)		1996-01 (a)		2001 Census date ERP (a)		1996-01 South Australia	
Age	Males	Females	Males	Females	Males	Females	Males	Females
0-4	21.59	17.21	17.75	21.74	13.43	12.84	7.01	30.91
5-9	17.65	13.55	25.93	20.77	14.09	12.97	31.36	36.42
10-14	15.61	12.93	15.48	14.31	12.81	11.82	5.67	13.76
15-19	8.89	8.66	0.54	1.94	10.34	9.98	12.16	2.57
20-24	7.25	9.05	-2.11	0.18	8.17	8.14	3.85	-8.85
25-29	3.08	7.45	2.14	6.77	7.94	8.38	7.18	0.36
30-34	3.39	6.86	5.44	6.37	7.28	7.92	4.92	-5.65
35-39	4.96	6.48	8.39	8.15	6.42	6.95	1.63	-5.24
40-44	4.43	4.84	7.66	3.78	5.48	5.68	9.62	9.72
45-49	4.63	3.83	6.68	3.91	4.37	4.51	-0.56	6.31
50-54	3.28	2.42	4.57	3.33	3.35	3.47	8.35	7.83
55-59	1.80	1.99	1.82	1.83	2.24	2.32	3.17	1.17
60-64	1.50	1.70	2.59	3.36	1.59	1.81	1.62	8.94
65-69	0.78	1.07	1.12	0.25	1.09	1.24	2.45	-1.02
70-74	0.15	0.60	0.20	-0.11	0.65	0.86	1.69	0.44
75 and over	1.00	1.37	1.80	3.42	0.75	1.11	-0.13	2.32
All ages	100	100	100	100	100	100	100	100

(a) Distributions for 1991-96, 1996-01 and 2001 Census ERP are for Australia.

Results

Table 4 gives the results of the analysis. A description of data in each column will help expedite the table.

Column 3 : is the per cent exponential annual population growth rate between 1996 and 2001.

Column 4 : is the expectation of life at birth based on observed age-specific death rates calculated from registered intercensal (1996-2001) deaths and mid-year population estimate between 1996 and 2001. Abridged life tables to age 85+ were calculated using standard demographic procedures.

Column 5 : is the consistency factor by which the observed age-specific death rates must be adjusted (multiplied by 1/consistency factor) in order that the Brass Growth Balance Equation between the population estimates (at 30 June 1996 and 2001) and the 1996-2001 registered deaths by age is balanced. In this instance no adjustment for 'identification migration' was introduced.

Column 6 : is the expectancy of life at birth that would result under the assumptions of Column 5. As most of the consistency factors were lower than 1, the adjustment to the age-specific death rates involved increasing them. The derived life expectancies at birth are consequently lower than those observed in Column 4.

Columns 7 and 8 : provide life expectancies at birth that would result by applying Bhat's modification to Brass Growth Balance Equation while assuming the difference between the observed growth rate and two assumed growth rates of the population (2.5% and 2.0% per annum) to represent the level of 'identification migration' and using the 1996-2001 age distribution of 'identification migration'. The corresponding difference in life expectancy at birth (at 2% annual growth rate) and observed growth rate (column 6) is given in column 9. The expectancies of life at birth are reduced by 3 to 4 years, the reduction is higher where the level of 'identification migration' was large (eg NSW). For the Northern Territory, the assumed growth rate (2% per annum) was higher than the observed growth rate for females (1.7%) and persons (1.8%), which gave slightly higher expectancies of life at birth than under the observed growth rate assumption.

Table 4: Observed and assumed intercensal annual growth rate of population and resulting expectation of life at birth, Bhat method, 1996-01

State or territory	Sex	1996-01 annual growth rate	Observed e(0)	Consistency factor for adjusting observed age-specific death rates under observed growth rate	e(0) under observed growth rate	e(0) values under the 1996-01 age distribution of identification migration and varying growth rates		Difference in e(0) values, Column 8 - column 6	Difference in e(0) values from Australia at 2% growth rate
						2.5%	2.0%		
		%	Years	Number	Years	Years	Years	Years	Years
1	2	3	4	5	6	7	8	9	10
NSW	Males	4.4	72.1	0.709	67.7	64.9	64.1	-3.7	2.3
	Females	3.8	77.7	0.651	73.2	70.7	69.8	-3.3	1.9
	Persons	4.1	75.0	0.679	70.4	67.6	66.7	-3.6	2.0
Victoria	Males	4.3	68.3	0.734	64.1	61.6	61.0	-3.1	-0.8
	Females	4.1	75.5	0.594	69.6	67.8	67.3	-2.2	-0.6
	Persons	4.2	71.9	0.654	66.4	64.3	63.7	-2.7	-1.0
Qld	Males	3.5	66.0	0.822	63.1	61.5	60.8	-2.4	-1.0
	Females	3.8	71.5	0.841	69.3	66.9	66.0	-3.3	-1.9
	Persons	3.7	68.8	0.841	66.4	64.2	63.4	-3.0	-1.3
SA	Males	3.1	62.7	0.983	62.5	61.2	60.1	-2.4	-1.6
	Females	2.8	70.2	1.170	72.2	71.4	70.2	-2.0	2.3
	Persons	2.9	66.4	1.067	67.3	66.3	65.1	-2.2	0.4
WA	Males	3.4	62.0	1.074	63.1	61.7	60.9	-2.3	-0.9
	Females	3.0	69.1	1.242	71.9	70.8	69.7	-2.2	1.8
	Persons	3.2	65.5	1.147	67.5	66.1	65.2	-2.3	0.5
Tas (a)	Males	2.7	na	na	na	na	na	na	na
	Females	2.4	na	na	na	na	na	na	na
	Persons	2.5	na	na	na	na	na	na	na
NT	Males	2.0	59.0	0.915	57.6	58.4	57.6	0.1	-4.1
	Females	1.7	64.5	1.046	65.2	66.7	65.7	0.5	-2.2
	Persons	1.8	61.7	0.975	61.3	62.5	61.6	0.3	-3.1
ACT (a)	Males	5.1	na	na	na	na	na	na	na
	Females	4.7	na	na	na	na	na	na	na
	Persons	4.9	na	na	na	na	na	na	na
Aust	Males	3.6	66.4	0.872	64.4	62.6	61.7	-2.7	0.0
	Females	3.3	72.3	0.873	70.6	68.9	67.9	-2.6	0.0
	Persons	3.4	69.3	0.872	67.5	65.6	64.7	-2.7	0.0
Aust (b)	Males	3.6	65.9	0.863	63.7	61.9	61.1	-2.6	-0.6
	Females	3.4	71.8	0.875	70.2	68.5	67.6	-2.6	-0.4
	Persons	3.5	68.8	0.868	66.9	65.1	64.2	-2.7	-0.5

(a) Not calculated due to too few deaths.
(b) Australia excluding Tas and ACT.

A sensitivity analysis of the difference in the expectation of life at birth, using different population growth rates and different age distributions of 'identification migration' is presented in Table 5. Column 3 in this table is the same as column 6 in Table 4. It gives the expectation of life at birth adjusted by Bhat method without making an adjustment for 'identification migration'. Columns 4 and 5 of Table 5 show the reduction in expectation of life at birth values when two levels of 'identification migration', varying for each state and the Northern Territory, are introduced with the 2001 Census-based ERP age distribution for Australia as the age distribution of 'identification migration'. As can be seen in Columns 4 and 5 of Table 5 the difference in life expectancies at birth is 0.6 years or less across the states, the Northern Territory and Australia. This indicates that the use of the 2001 age distribution of population as the age distribution of 'identification migration' and a substantial level of 'identification migration' reduces the life expectancy at birth estimates only marginally.

Columns 6 and 7 of Table 5 provide similar calculations to those given in columns 4 and 5 for the difference in life expectancies at birth using the 1991-96 age distribution of 'identification migration'. Again, the effect is a reduction of about 0.5 years or less in the expectations of life at birth from values given under no 'identification migration' assumption (column 3).

Columns 8 and 9 of Table 5 repeat the calculations using the 1996-2001 age distribution of 'identification migration' as obtained for South Australia. As seen in Table 3, these age distributions for South Australia are older than the 1991-96 or the 1996-2001 similar distributions for Australia. Column 8 and 9 show a large reduction in the life expectancy at birth estimates from those calculated under the observed population growth rate assumption (column 3) and no 'identification' migration'.

From the above calculations it is clear that the level of 'identification migration' combined with a selected age distribution of 'identification migration' reduces the life expectancy at birth estimates from those calculated using no 'identification migration'. The range of difference in the derived expectancies of life at birth can be quite large depending upon the used younger or older age distribution of 'identification migration'. Whether the 'true' population growth of the Indigenous population is 2.5% or 2% per annum for 1996-2001 makes a small difference in the calculated life expectancies at birth as long as both of these are calculated from the same age structure of 'identification migration'.

Table 5: Difference in expectation of life at birth derived from different growth rates and age distributions of identification migration and 2% growth rate and the 1996-01 age distribution of identification migration, Bhat method, 1996-01

State or territory	Sex	Adjusted e(0) under the observed growth rate	Difference in e(0) derived under the specified assumptions and those derived (adjusted) under observed growth rate: 2001 age distribution of ERP as age distribution of identification migration and varying growth rates		1991-96 age distribution of identification migration and varying growth rates		1996-01 age distribution of identification migration of South Australia and varying growth rates	
			2.5%	2.0%	2.5%	2.0%	2.5%	2.0%
		Years	Years	Years	Years	Years	Years	Years
1	2	3	4	5	6	7	8	9
NSW	Males	67.7	-0.5	-0.6	-0.4	-0.5	-5.7	-7.0
	Females	73.2	-0.3	-0.4	-0.2	-0.2	-8.5	-10.9
	Persons	70.4	-0.4	-0.5	-0.3	-0.4	-7.9	-9.8
Victoria	Males	64.1	-0.1	-0.2	-0.2	-0.3	-4.3	-5.3
	Females	69.6	0.1	0.1	0.2	0.2	-6.5	-8.1
	Persons	66.4	0.0	0.0	0.0	0.0	-5.8	-7.2
Qld	Males	63.1	0.0	0.0	-0.3	-0.5	-3.2	-4.6
	Females	69.3	-0.1	-0.2	-0.3	-0.4	-7.8	-10.0
	Persons	66.4	-0.1	-0.1	-0.4	-0.5	-5.7	-7.7
SA	Males	62.5	-0.1	-0.1	-0.3	-0.6	-2.2	-4.0
	Females	72.2	-0.1	-0.2	-0.1	-0.2	-2.8	-6.8
	Persons	67.3	-0.1	-0.2	-0.2	-0.4	-3.0	-5.9
WA	Males	63.1	0.0	0.0	-0.2	-0.3	-2.9	-4.5
	Females	71.9	-0.1	-0.1	-0.1	-0.1	-4.3	-7.7
	Persons	67.5	-0.1	-0.1	-0.1	-0.2	-4.0	-6.5
Tas (a)	Males	na	na	na	na	na	na	na
	Females	na	na	na	na	na	na	na
	Persons	na	na	na	na	na	na	na
NT	Males	57.6	0.0	0.0	0.2	0.0	1.9	0.1
	Females	65.2	0.0	0.0	0.0	0.0	6.7	2.2
	Persons	61.3	0.0	0.0	0.2	0.0	4.0	0.9
ACT (a)	Males	na	na	na	na	na	na	na
	Females	na	na	na	na	na	na	na
	Persons	na	na	na	na	na	na	na
Aust	Males	64.4	-0.1	-0.2	-0.3	-0.5	-3.6	-5.0
	Females	70.6	-0.1	-0.2	-0.1	-0.2	-6.0	-8.7
	Persons	67.5	-0.1	-0.2	-0.2	-0.4	-5.1	-7.3
Aust (b)	Males	63.7	-0.1	-0.2	-0.3	-0.4	-3.5	-4.9
	Females	70.2	-0.1	-0.2	-0.1	-0.2	-6.0	-8.7
	Persons	66.9	-0.1	-0.2	-0.2	-0.3	-5.1	-7.2

(a) Not calculated due to too few deaths.
(b) Australia excluding Tas and ACT.

Despite various limitations of the calculated age distributions of 'identification migration' for Australia for the 1996-2001 period, it is probably the best available for use in Bhat's modification of the Brass Growth Balance Equation noting that (i) it is for the same time period for which the life table is calculated, and (ii) is an aggregate for all the states and territories which individually show a large variation in the age distribution of 'identification migration'. The growth rate of Indigenous population is probably more closer to 2% per annum (looking at the Northern Territory's population growth rate of 1.8% per annum during 1996-2001) than 2.5% per annum.

Discussion

Given a 2% annual growth rate as the 'true' growth rate of the Indigenous population during 1996-2001 and the 1996-2001 age distribution of 'identification migration' for Australia as representative for all the states and territories and Australia, the life expectancy at birth estimates (as calculated in column 8 of Table 4) can be regarded as a close approximation of Indigenous mortality in Australia. Column 10 of Table 4 shows the difference in the derived life expectancy at birth estimates of each state and territory from the corresponding estimates for Australia. According to the calculations, Indigenous persons in NSW and females in WA and SA have nearly 2 years higher life expectancy than Australian equivalents. Lower than Australian life expectancies at birth are for all other jurisdictions, the maximum difference found is for the Northern Territory (4 years less for males and 2 years less for females). The Australian Indigenous life expectancies at birth are 61.7 years for males, 67.9 years for females for 1996-2001. These are nearly 16 years lower than the life expectancies at birth for the total population of Australia in 2000-2002 (77.4 years for males and 82.6 years for females). It should be noted that the estimates of Indigenous life tables, being based on small number of deaths, have large standard errors. The confidence limits for the estimates for 1996-2001 are 60.9-62.6 years for males and 67.0-68.8 years for females.

As noted, the age distribution of 'identification migration' in combination with the level of 'identification migration' has a large impact on the derived life expectancies at birth values for Indigenous people for various jurisdictions. The estimates provided here although appear plausible are one such set of values which are based on specific assumptions used in their derivation. Needless to mention that the results will change according to the assumptions used.

Conclusion

Indigenous death registrations and the Indigenous population estimates are deficient in several ways and no direct measures of mortality can be calculated from these data at present. Indirect methods of mortality estimation provide interim measures of mortality for a population for which death registration is deficient. They are not a replacement of mortality indicators which are calculated from the correct data on recorded deaths and population which both are consistent with one another. An indirect technique, the Brass Growth Balance Equation is fitted in this paper, with and without adjustment for the unusually high population growth rate of Indigenous population during the 1996-2001 intercensal period. It is shown that without an adjustment of the high intercensal growth rate of the population, the derived expectancies of life at birth are nearly 4 years higher than with an adjustment which allows for the level as well as the age distribution of the unaccountable growth, termed as 'identification migration'. The derived life expectancies at birth with adjustment are nearly 16 years lower for the Indigenous population (61.7 years for males and 67.9 years for females) during 1996-2001 compared with 77.4 years for males and 82.6 years for females during 2000-2002 for the total Australian population. There are state and territory variations. On one extreme the NSW life expectancy at birth is nearly 2 years higher and that of the Northern Territory is 2 to 4 years lower than for the total Indigenous population in Australia. No life tables are calculated for Tasmania or the Australian capital Territory as each recorded a small number of Indigenous deaths. Perhaps the life expectancy values for NSW can be applied to these two jurisdictions.

Several assumptions are involved in using the indirect techniques of mortality estimation and any indirect estimate should be treated with caution as a slight change in the assumptions can affect the derived measures. In this light, some subjective judgement may be necessary in using the derived indirect measures of mortality for their further use in any demographic analysis.

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