Demographic characteristics and trends of the Northern Territory Indigenous population, 1966 to 2001

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Summary

No time-series of population estimates, births or deaths data for Indigenous Australians over recent decades have previously been available. Although it is apparent that the Australian Indigenous population has very different demographic characteristics to the total Australian population, with a younger age distribution, higher fertility and much higher mortality rates, changes in these characteristics cannot be monitored over recent decades. Information on Indigenous mortality trends, one of the most basic measures of overall health status, is not available to monitor improvements, or lack thereof, in Indigenous health.

Demographic data is more reliable, and more readily available, for the Indigenous population of the Northern Territory (NT) than for Indigenous people in other parts of Australia. Using available data from original death registration records and the most recent estimates of the size and age distribution of the NT Indigenous population, reliable and consistent data on population estimates and deaths from 1966 to 2001 have been produced for the NT Indigenous population. These are the only long-term time-series data on recent demographic trends for any Australian Indigenous population currently available.

Between 1966 and 2001 major demographic changes occurred in the NT Indigenous population. The total population size more than doubled and the age-distribution became 'older'. The proportion of the population aged 0-9 years decreased from 32% to 24%, while the proportion aged 20-39 years increased from 26% to 34%. However the proportion aged over 65 years did not increase. The general fertility rate declined by 50%. Age-specific mortality rates declined considerably for females, and to a lesser extent for males. Mortality rates declined in all age-groups, by over 85% in age-group 0-4 years for both males and females, and by between 10% and 50% in older age groups.

These changes demonstrate that a demographic transition has been under way in the NT Indigenous population for at least the past four decades. Declining Indigenous mortality rates in the middle adult years are particularly encouraging, as previous reports on Indigenous mortality over shorter periods have not demonstrated improvement in adult mortality.

1. Introduction

In recent years considerable effort has been made to measure the impact of health and other social services on the poor health status of Australia's Indigenous populations.[1,2] Even for such basic measures as mortality, however, this has proven difficult due to limitations in the availability and quality of relevant data.[3] The exception has been the major reductions in Indigenous infant mortality that occurred during the 1970s.[4,5] Convincing evidence of improvements (or lack thereof) in other age-groups has proven more elusive.

Although demographic information remains incomplete for the Indigenous population, there have been considerable improvements in the availability of, and our understanding of, Indigenous demographic data in the past decade.[6-8] Even with imperfect data it is apparent that, compared to the total population, the Indigenous population is characterized by high fertility, high mortality and a young age distribution.[3] However, little reliable information is available on demographic *trends* for the Indigenous population, the type of information required to measure the impact of services and programs. Because there have been major changes in census counting methods between censuses, it cannot be assumed that census counts are consistent from one census to another.[6] Even in the past decade, internally consistent estimates of the Indigenous population are only available within five-year periods and death data are known to be incompletely recorded in most states.[9,10]

Demographic data are more consistent over time for the Indigenous population of the Northern Territory (NT) than for other states and territories.[6-8,11,12] Although continuing census enumeration problems have been reported in Indigenous communities in the NT,[13] there has been a very low level of variation in Indigenous population counts between censuses due to changing propensity to identify as Indigenous, unlike all other Australian states and territories in recent decades.[6] In addition, recording of Indigenous status in NT birth and death registrations, which commenced in 1988, is estimated by the Australian Bureau of Statistics (ABS) to be more complete than in any other state or territory.[7,8] However, no reliable long-term time-series data have been published on demographic trends in the NT Indigenous population in recent decades.

It is possible to reconstruct a consistent time-series of Indigenous population estimates for the NT if net interstate and overseas migration of NT Indigenous residents is nil, all Indigenous deaths of NT residents are registered and can be identified as Indigenous and an accurate recent estimate of the Indigenous resident population is available. These three conditions are reasonably well satisfied for the NT Indigenous population (see Section 2).

This paper describes work in which the Indigenous status of residents of the NT who died since 1967 has been carefully reviewed and reconsidered, allowing the NT's Indigenous population to be reconstructed in a manner which enables trends in mortality and other demographic population characteristics over the past four decades to be assessed with confidence for the first time.

A consistent time-series of deaths data has been produced for Indigenous residents of the NT from 1967 to 2001. Using this deaths dataset and the ABS experimental estimates of the NT Indigenous resident population for 30 June 2001, a back-casting method was used to construct a consistent time-series of NT Indigenous population estimates for 30 June each year from 1966 to 2001. The number of Indigenous births can also be estimated by this back-casting method. These time-series of NT Indigenous population estimates, births and deaths have been used to study trends over 35 years in population growth, age distribution, fertility and mortality.

This paper presents the main results of this analysis of changes in the demographic characteristics of the Indigenous population of the NT from 1966 to 2001.

2. NT Indigenous demographic data sources

2.1. Population estimates

A thorough review of data on estimates of the NT Indigenous population up to the early 1970s found that there were no reliable estimates for the NT Indigenous population before 1920.[14] Censuses, including special Aboriginal Censuses conducted nationally each year from 1924 to 1944, were only able to enumerate part of the Indigenous population; until the 1966 Census, estimates of the NT Indigenous population included an approximation of the number of Indigenous people 'out of contact' to the census enumeration process. The most accurate estimates of the NT Indigenous population were those produced by the NT Administration (part of the Commonwealth Government from 1911 to 1978) after 1955. These estimates were based on a register of Aboriginal people who were under the legal control of the Welfare Division of the NT Administration; the register, called the Aboriginal Population Record, commenced in 1955. Aboriginal people were included in the register if they were thought to be of 50% or more Aboriginal ancestry; Aboriginal people of lesser ancestry were also under 'control' if they lived with other Aboriginal people who were of at least 50% Aboriginal ancestry. Only a small proportion of NT Aboriginal people were not included in the register; 9% in 1960, 21% in 1971.[14] The NT Administration estimates for 1966 and 1971 were several thousand higher than Census counts for the same years. The NT Administration ceased producing estimates of the Indigenous population based on the Aboriginal Population Register in the early 1970s.

Census counts of the Indigenous population since 1966 have not included estimates of Aboriginal people 'out of contact' in the NT because the ABS claimed to have been potentially able to contact all Aboriginal people during the enumeration process.[14] However, the enumeration of Indigenous people, like that of the total population, is never complete in any Census. The Census count was 7.5% less than the NT Administration estimate in 1966 (22,312 c/w 24,120) and 18% lower in 1971 (23,381 c/w 28,500). Estimates of the NT Indigenous population produced by the ABS in the 1990s were 8-12% higher than Census counts of Indigenous people (Table 1, Figure 1). Census counts are also inconsistent over time. Between 1971 and 1976 the Indigenous census count increased by only 1.6% but then increased by 22.5% between 1976 and 1981 (Table 1).

Table 1 Australian Bureau of Statistics counts and estimates of the Northern Territory Indigenous population in census years [14,16-20]

	Census counts				NT Admin. estimates		
Year	Aboriginal[a]	Indigenous[b] (place of enumeration)	Indigenous[b] (place of residence)	Out of Contact	'Controlled'	Total	ABS Indigenous[b] population estimate
1901	np	23 235	np	np			23 235
1911	np	1 467	np	np			22 000
1921	np	2 510	np	np			17 809
1933	np	6 590	np	np			19 386
1947	12 232	np	np	np			15 147[a]
1954	11 788	11 794	np	5 369			17 163
1957					17,371	17,400	
1960					18,329	20,200	
1961	17 760	17 763	np	1 944	18,677	np	19 707
1966	22 312	np	np	0	20,134	24,120	np
1971	23 253	23 381	np	np	22,396	28,500	np
1976	23 535	23 750	np	np			np
1981	28 679	29 089	np	np			np
1986	np	34 738	34 679	np			38 885
1991	np	39 910	39 857	np			43 273
1996	np	46 277	46 362	np			51 876
2001	np	50 785	50 845	np			56 875

a. excludes Torres Strait Islanders

b Aborigines and Torres Strait Islanders

np. not published

Prior to 1971 the Bureau of Statistics classified people as 'full-blood Aboriginal' if they were deemed have a majority of ancestors who were Aboriginal, and as 'half-caste Aboriginal' if half their ancestors were Aboriginal. People with less than 50% Aboriginal ancestry were not classified as Aboriginal, and they were identified separately only in 1966. Obviously this rigid classification was impossible to apply consistently in practice, particularly in the case of people whose racial classification was different from others in their family or community. Torres Strait Islanders were not regarded as 'aboriginal natives' and were classified separately to Aborigines, although not consistently from one census to another.

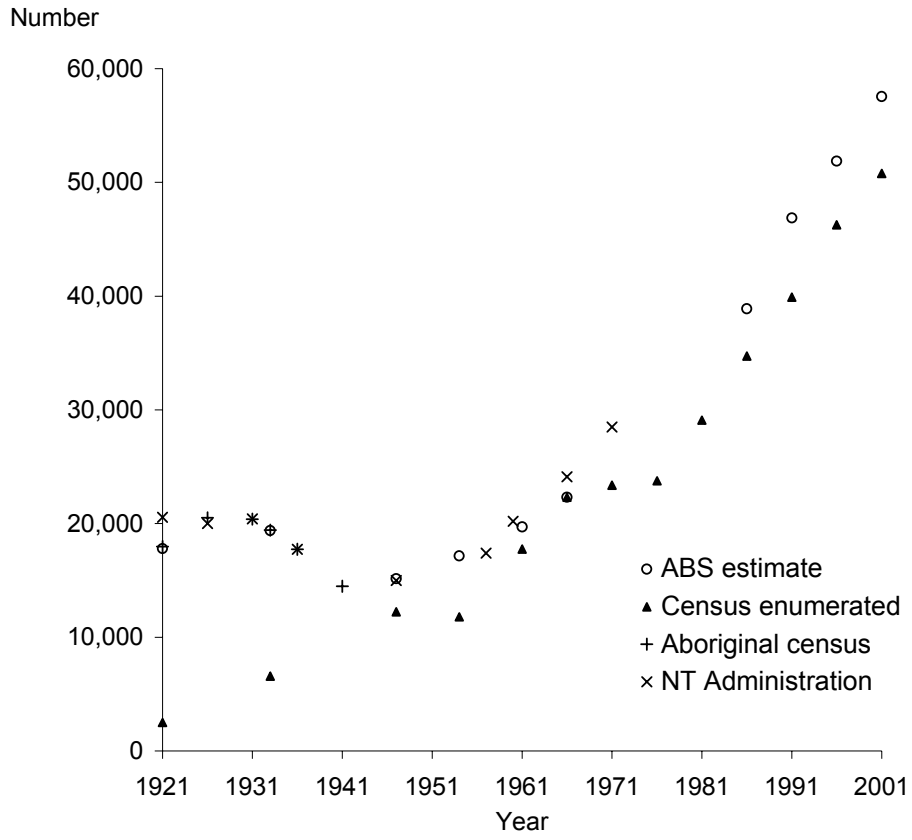

Figure 1 Estimates and census counts of the NT Indigenous population, 1921-2001

Since 1971 Indigenous people (both Aborigines and Torres Strait Islanders) have been identified in the census by direct question based on Aboriginal or Torres Strait Islander descent, although the details of the question have changed over time.[6] The propensity of people to identify as Indigenous has changed considerably over time, leading to very large increases in the Indigenous population from one census to the next (particularly in the eastern states) which cannot be explained by natural population increase. However, changes in propensity to identify as Indigenous in the NT have been small compared to changes that have occurred in other states. This is partly because the majority of the NT Indigenous population live in isolated Aboriginal communities and the NT Indigenous population has a smaller proportion of people of mixed descent than the Indigenous population of other states.[6]

The ABS did not produce intercensal estimates of the NT Indigenous population between 1966 and 1986; only census counts were published during this period. The longest internally consistent time-series of Indigenous population estimates produced for the NT in recent decades are for five-year periods only (1986—1991 and 1991—1996). After the 1991

Census, the ABS produced the first Indigenous population estimates since 1961. Indigenous estimates were produced for each state and territory, and for Australia as a whole.[15] These estimates were calculated by multiplying the Census counts by adjustment factors to compensate for under-enumeration in the Census.[15] The adjustment factors were calculated within strata of age-group, sex and state. The adjustment factors for the Indigenous population used in 1991 were the same at the adjustment factors used for the total Australian population. These adjustment factors are calculated by matching the results of the Census Post-enumeration Survey (PES) with the data collected for the same households in the Census, and estimating the number of people missed by the Census. The ABS back-cast these Indigenous population estimates to produce a time-series for 1986—1991.

Indigenous population estimates were also produced by the ABS after the 1996 Census. At that time, the ABS recognised that Census under-enumeration was greater for Indigenous people than for the total population and that separate adjustment factors were required when calculating indigenous population estimates. The ABS also recognized that the level of under-counting would not be the same in all strata of age-group, sex and state. However, the PES included only enough Indigenous households to estimate a single, national adjustment factor for Indigenous census counts (7.1%, compared to 1.5% for the non-Indigenous population).[9] Separate adjustment factors could not be calculated for individual strata of age-group, sex and state. Instead the overall Indigenous adjustment factor was varied within strata of age-group, sex and state according to the relative variation in these strata for the total Australian adjustment factors. A greater proportion of Indigenous people live in remote communities in the NT than in other states, but most non-Indigenous people live in urban areas in the NT, as elsewhere. If the undercount was relatively higher in the NT compared to the rest of Australia for Indigenous than non-Indigenous people, the adjustment factor for NT Indigenous people would have been too low and the population estimates would consequently have under-estimated the NT Indigenous population.

The 1991 Indigenous population estimates based on the 1996 Census are higher than the 1991 estimates based on the 1991 census (Figure 4) mainly because specific Indigenous adjustment factors were used for the 1996-based estimates, which were larger than the total Australian adjustment factors used for the 1991-based estimates.

The 2001 estimate of the Indigenous population is unlikely to be an over-estimate, but there are indications that it may be an underestimate. Indigenous counts and population estimates from the 1996 and 2001 Censuses have been relatively consistent in the NT. There has been very little change in propensity to identify as Indigenous in the NT.[6] However, the census enumeration process is particularly difficult in NT Indigenous communities, and evaluation of the process in two communities at the 2001 Census highlighted deficiencies which likely resulted in an under-count of the population, although not to a very large extent.[13] The adjustment factors used to calculate Indigenous population estimates were not specific for Indigenous populations in remote communities, and may have under-estimated the level of Census under-count for the Indigenous population, as discussed above.

2.2. Deaths data

Death registration in the NT is believed by registration authorities to be relatively complete from the late 1950s (personal communication, NT Deputy Registrar of Births, Deaths and Marriages), which is confirmed by a previous study of NT demographic data sources,[14] although there has never been an independent assessment of the completeness of registration.

Prior to 1967 Indigenous deaths were registered by the NT Registry of Births, Deaths and Marriages (BDM), but the ABS did not include data on deaths of people judged to be 'full-blood Aboriginal' in death statistics nor in the national deaths dataset.[14] The determination of who was to be excluded from ABS death statistics was based on the degree of Aboriginal ancestry of the deceased, as determined by ABS and BDM staff from information recorded in the death notification (personal communication, NT Deputy Registrar, BDM). People with 50% or more Aboriginal ancestry were excluded from deaths statistics.

Estimates of the size of the 'NT tribal Aboriginal population', and of the number of births and deaths in that population, derived from the Aboriginal Population Record, have been reported for the period 1957—1971 in a study of Indigenous demographic data sources up to the early 1970s[14] (Table 2).

Table 2 Estimated number of births and deaths in the NT Aboriginal tribal[a] population, 1957—1971, from records of the NT Administration

Year	Midyear population	Births	Deaths	Crude birth rate	Crude death rate
1957	17,208	637	259	.0370	.0151
1958	17,545	656	265	.0374	.0151
1959	17,877	687	319	.0384	.0178
1960	18,182	625	297	.0344	.0163
1961	18,503	689	299	.0372	.0162
1962	18,776	601	376	.0320	.0200
1963	19,035	636	276	.0334	.0145
1964	19,283	661	444	.0343	.0230
1965	19,526	661	306	.0339	.0157
1966	19,908	774	339	.0389	.0170
1967	20,342	761	343	.0374	.0169
1968	20,753	773	371	.0372	.0179
1969	21,175	816	377	.0385	.0178
1970	21,621	837	385	.0387	.0178
1971	22,052	779	367	.0353	.0166

In 1967 a successful referendum repealed Section 127 of the Australian Constitution which until that time excluded 'aboriginal natives' from the 'numbers of people of the Commonwealth'. From 1967 the ABS included all Indigenous deaths in national deaths data, with an indigenous identifier. However, death notification forms at that time did not include information on indigenous status, which continued to be inferred by ABS and BDM staff, although it appears from comparison of the ABS deaths dataset with original death registration records that not all Indigenous people were identified as such, possibly because the previous criteria based on Aboriginal ancestry continued to be used. Thus the number of NT deaths recorded as Indigenous in the national deaths dataset prior to 1988 under-estimates the true number of Indigenous deaths.

In September 1988 a question on indigenous status was added to death notification forms in the NT. From that time indigenous status recorded in the national deaths dataset is based on information provided by people completing death notification forms. There are usually three sources of notification for each death - a medical or coronial certificate of cause of death, a hospital or health centre notification of death, and a notification of burial from a funeral director. Interpretation by BDM staff is still occasionally required when the various

notification sources provide conflicting information on indigenous status (personal communication, NT Deputy Registrar, BDM).

Identification of Indigenous deaths in death registrations is close to complete since recording of indigenous status was added to death notification forms in 1988.[8] For deaths prior to 1988, indigenous status can be inferred with a high degree of accuracy from other information on the death registration.[21]

2.3. Births data

As with death registration, the births of Indigenous children were registered by the NT Registry of Births, Deaths and Marriages before 1967, but births of children deemed by ABS and BDM staff to have 50% or more Aboriginal ancestry were excluded from ABS birth statistics. Indigenous status was included in NT birth notification forms in 1988, and since then Indigenous identification in birth registrations in the NT is estimated to be close to complete.[7] Between 1957 and 1971 the NT Administration also estimated the number of Aboriginal births from the data collection systems of the Welfare Division (Table 2).

Births data are also available from the NT Midwives Collection, a data collection of clinical information about births in the NT maintained by the NT Department of Health and Community Services which commenced in 1986. The principle purpose of the Midwives Collection is monitoring of maternal and infant health status. Indigenous status is recorded for all births, and provides a semi-independent data source to estimate Indigenous births. However, the total number of births (Indigenous and non-Indigenous combined) recorded by the Midwives Collection is slightly lower than the number of birth registrations each year, indicating that not all births are notified to the Midwives Collection.[4,7]

2.4. Interstate migration

The assumption of nil net interstate migration is important to the accuracy of the back-cast population estimates. The Indigenous population of the NT appears to be close to a closed population geographically, and the ABS assumes it is closed in calculating Indigenous population estimates for states and territories.[9] Evidence from the five-yearly Australian Census suggests that net interstate migration is close to nil for the NT Indigenous population.[22] In the 1996 census, only 5% of respondents who indicated that they were Indigenous reported living interstate at the time of the previous census, compared to 34% of the non-Indigenous population. Net interstate migration of Indigenous people into and out of the NT is low; between 1991 and 1996 it was 0.6% of the 1996 census count of Indigenous people.

However, the evidence that NT Indigenous net migration is close to nil within each age-group is not conclusive,[6,23] and there are concerns about the accuracy of census data from remote Indigenous communities because of language, cultural and population mobility issues.[13,24]

3. Methods

3.1. Deaths data time-series

De-identified unit record data was obtained from the ABS for all deaths registered since 1967 in the NT and for deaths registered since 1967 in other Australian states and territories for which the NT was recorded as the state of residence. Data in the unit record file included date of death, date of birth (or age at death for registrations in earlier years), sex, indigenous status and state of residence. The death registration number was included for deaths registered in the NT, which enabled matching with death registration forms at BDM.

Indigenous status was included in NT death notification forms from 1988. The ABS has reported that, for NT death registrations from 1996-2001, Indigenous deaths may be under-identified by approximately ten percent, but cautions that the method used for this assessment is imprecise.[8] For deaths registered in the NT from 1967—1988, indigenous status was inferred from other information in the death registration. In the NT most Indigenous people are readily identified in death registrations by one or more factors including:

a distinctive Aboriginal name in one of the local Aboriginal languages

a name of one of the extended Aboriginal families that are long-established in NT urban communities

having one or both parents, or children, with distinctive Aboriginal names

a place of birth in a remote Aboriginal community, or in the Torres Strait

marriage status recorded as 'tribally married'

burial in a remote Aboriginal community

a burial service performed by a pastor of the Aboriginal Inland Mission,

a combination of several suggestive factors such as a parent's name which was commonly assigned by early pastoralists to Aboriginal people (such as Topsy, Smiler or Tracker) plus birth in an NT town plus residence in a remote Aboriginal community or cattle station.

If a death registration had one or more of these factors, indigenous status was assigned as Indigenous. If none were present or there was a clear indication that the person was unlikely to be Indigenous (such as being born overseas), the death was assigned as non-Indigenous. Registrations with inconclusive indications, such as a person with a surname of an urban

Aboriginal family but an interstate place of birth and no other indications that they were Indigenous, were assigned as non-Indigenous. To enhance consistency of inferral of indigenous status over time all inferral was done by one person (JRC).

Retrospective inferral of indigenous status was validated in a previous study in which inferred indigenous status was compared with indigenous status reported in death notifications and found to have a high level of agreement.[21] In this previous study Indigenous status was inferred for 349 deaths registered during 1991, after the notified indigenous status was concealed from the person (JRC) doing the inferral (Table 3). Notified and inferred indigenous status agreed for 94% of deaths. Of the 6% of deaths where there was disagreement, 4% were Indigenous people incorrectly inferred as non-Indigenous and 2% were non-Indigenous incorrectly inferred as Indigenous (assuming the notified indigenous status is correct). The Predictive Value Positive of inferred indigenous status was 0.975 and Predictive Value Negative was 0.917, compared to notified indigenous status.[21]

Table 3 Validation of indigenous status inferral

	Notified [a]		
Inferred [b]	Indigenous	Non-Indigenous	Total
Indigenous	167	4	171
Non-Indigenous	8	170	178
Total	175	174	349

a. as recorded in the death registration from death notification forms

b. inferred from other information in the death registration

For deaths of NT residents that were registered interstate, indigenous status as recorded in the ABS deaths dataset was taken as being correct because access to death registration forms was not possible. There were 25,376 deaths of NT residents between 1967 and 2001, of which 1,337 (5.3%) were registered in states other than the NT. Nine percent (53 of 544) of interstate registrations were recorded as Indigenous in the period 1967—1986 compared with 36% (268 of 740) in 1987—2001. There would have been an additional 163 Indigenous deaths in 1967—1986 if 36% of interstate deaths were Indigenous in that period. This would have increased Indigenous deaths in that period by 2.2%.

Date of birth was not recorded on NT death registrations until 1994; only age at death was recorded in prior years. Approximate date of birth calculated from date of death and age at death can be used if deaths occur uniformly within the year between birthdays. This is a reasonable assumption except for the first year of birth, since infant deaths occur more commonly in the first few weeks after birth than later in the first year of life. For deaths registered with only age at death recorded, date of birth was estimated as date of death minus (age at death plus 182 days). For infants who died in the first year of life, the date of birth was estimated as date of death minus 91 days.

A high proportion of older Indigenous people in the NT do not know their exact age and have only an approximate year of birth. For most of these older people their approximate year of birth was first recorded many decades ago when they were children or young adults by missionaries, cattle station operators or government officials at the time of first 'settlement'. Although it is not possible to be certain, approximate year of birth is probably accurate to within a few years.

3.2. Population data time-series

In a closed population (ie, with no inward or outward migration), births constitute the only entry into the population and deaths the only exit. From an accurate estimate of the population size at a particular point in time *t*, the size of the population at a future point in time *t+1* can be calculated by adding the number of births and subtracting the number of deaths that occurred in the intervening period *t:t+1*. If the date of birth and date of death of deceased people are known, the age structure of the population can also be calculated. If P^t is the population size at time *t* and P^{t+1} is the population size at time *t+1*, $B^{t:t+1}$ is the number of births in period *t:t+1* and $D^{t:t+1}$ is the number of deaths in period *t:t+1*, then:

$$P^{t+1} = P^t + B^{t:t+1} - D^{t:t+1}$$

Similarly, population size and age distribution can be calculated for a *prior* point in time *t-1*. Going backwards in time, the people 'entering' the population between time *t* and the prior time *t-1* are those who died in the intervening period *t-1:t*. People 'leaving' the population are those who were born during the same period. The population at time *t-1* is thus:

$$P^{t-1} = P^t - B^{t-1:t} + D^{t-1:t}$$

Provided that the period *t-1:t* is of the same duration as the span of years in each age-group of the population estimate at time *t,* the quantity $B^{t-1:t}$ (the number of births in period *t-1:t*) can be calculated from P_0^t (the number of people in the youngest age-group *0* at time *t*) and ${}_{t-1:t}D^{t-1:t}$ (the number of deaths during period *t-1:t* of people who were born in period *t-1:t* and thus would have been in the youngest age-group *0* at time *t* had they not died):

$$B^{t-1:t} = P_0^t + {}_{t-1:t}D^{t-1:t}$$

The population at time *t-1* can thus be calculated as:

$$P^{t-1} = P^t - (P_0^t + {}_{t-1:t}D^{t-1:t}) + D^{t-1:t}$$

Thus all that is required to calculate the population size and age distribution for a prior point in time in a closed population is an accurate estimate of the population size and age distribution at a recent point in time and accurate deaths data (including date of death and date of birth) for all deaths that occurred in the intervening period. Births data are not required since all people in the youngest age-group leave the population in each 'back-cast' time period; this provides an indirect estimate of the number of births in each period.

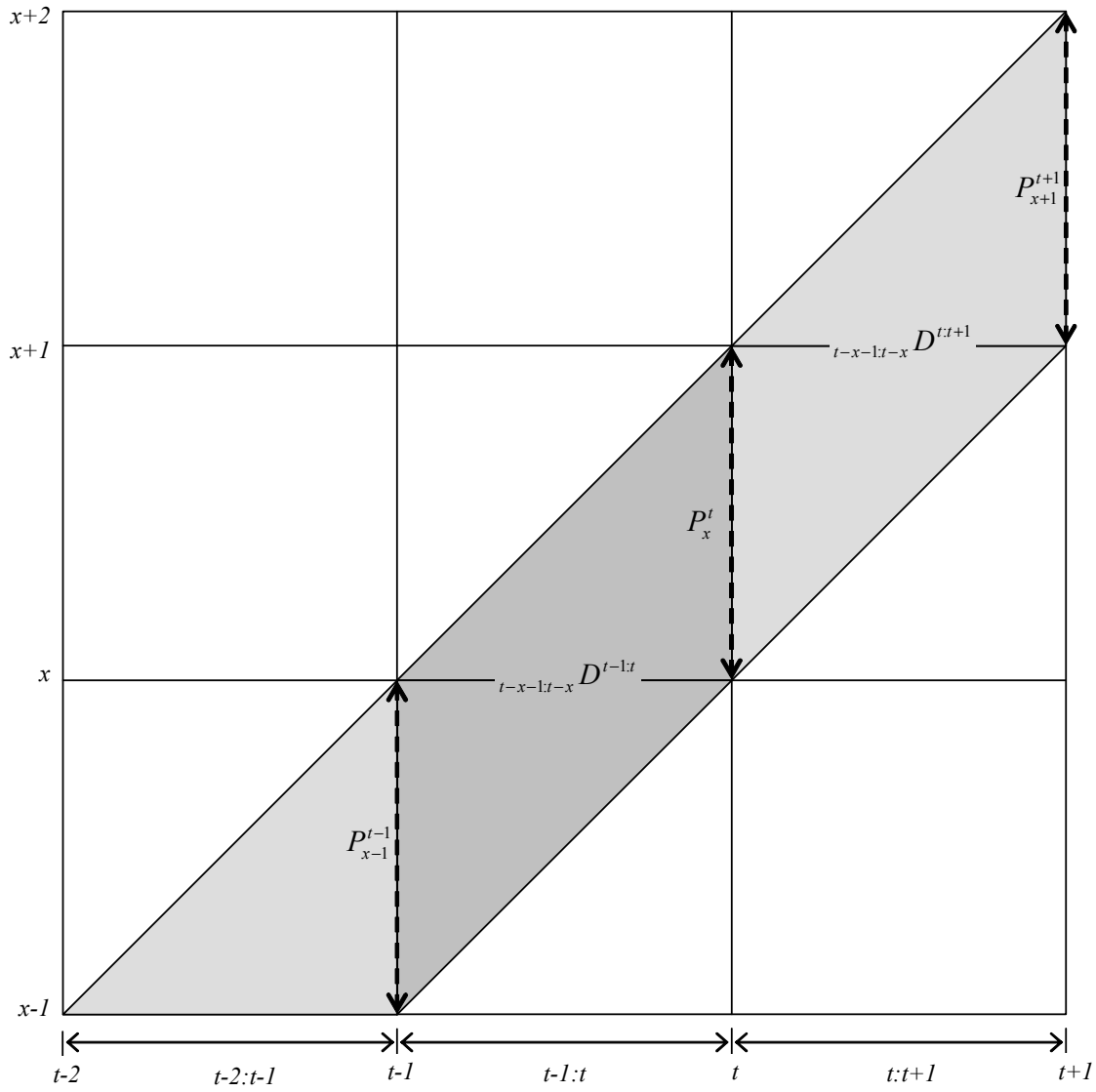

Figure 2 Relationship between population estimates in age-groups, birth cohort and deaths

The age distribution of the population can be estimated by applying the back-casting method within age-groups (Figure 2). Each death much be assigned to the relevant period of death and the relevant birth cohort of the deceased. The birth cohort of age-group *x* at a time *t* are people born in the period *t-x-1:t-x*. If age-groups at time *t* are of five-year rather than one-year age span, the birth cohort would be people born in the period *t-x-5:t-x*. For example, the birth cohort for the population aged 40-44 at 30 June 2001 consists of people born between 1 July 1956 and 30 June 1961 inclusive (ie, 2001-40-5=1956 to 2001-40=1961).

The most recent estimates of the NT Indigenous population size and age distribution are for 30 June 2001.[25] These estimates are produced in five-year age-groups. Back-casting of the population was based on these estimates and therefore calculated for five-year intervals, ie, to 1996, 1991, etc, and interpolated for intervening years. The number of births in each five-year period was estimated by the number of people subtracted from the population in each period, which is the quantity ($P_0^t + {}_{t-1:t}D^{t-1:t}$) in the formula

$P^{t-1} = P^t - (P_0^t + {}_{t-1:t}D^{t-1:t}) + D^{t-1:t}$.

3.3. Births data time-series

The number of NT Indigenous births between 1966 and 2001 was estimated from the back-casting method for five-year periods for financial years (1 July to 30 June). Estimates were for financial year rather than calendar year periods because the back-casting method estimated mid-year population estimates and the number of births was estimated as the number of people subtracted from the population in each five-year period (from mid-year to mid-year). When projecting backwards, the number of people in age-group -5 to 0 years for each five-year interval was the estimated number of births in that five-year period. This was calculated from the number in age-group 0-5 years in the population estimate for the year at the end of each five-year period plus the number of deaths of children belonging to the corresponding birth cohort. The number of births for individual years was not estimated.

3.4. Statistical analysis

Fertility

The General Fertility Rate (GFR) was calculated for five-year periods as the estimated number of births in each period divided by the estimated number of person-years of women aged 15-49 in each period. The periods used for calculation of fertility rates were from 1 July to 30 June rather than calendar years because the back-cast method produces population estimates for 30 June at five-year intervals and the number of births for the intervening periods. The denominator was the sum of the number of women aged 15-49 at 30 June for each calendar year within the five-year period plus the mean of the number of women at 30 June at the beginning and end of the five-year period. Age-specific and Total Fertility Rates could not be calculated because no data for or estimates of the age of mothers were available.

The Australian GFR was calculated for four-year periods consisting of the four middle calendar years for each five-year period (from 1 July to 30 June) for which the NT Indigenous GFR was calculated. Within each time period the Australian GFR was age-standardised (in five-year age-groups) to the age distribution of NT Indigenous females aged 15-49 years using published Australian age-specific fertility rates.[26,27] GFRs were not age-standardised between time-periods because age-specific fertility rates were not available for the NT Indigenous population.

The crude birth rate was calculated for comparison with the crude birth rate estimated for the NT Indigenous population in the period 1957—1971. The crude birth rate was calculated as the estimated number of births in each five-year period divided by the sum of the estimated total population for each of those five years calculated in the same way as the denominator of the GFR.

Mortality

Mortality rates were examined separately for males and females in five age-groups (0-4, 5-24, 25-44, 45-64 and 65+) from 1967 to 2000, based on year of death rather than year of registration. Negative binomial regression models were used to calculate the average annual change in mortality rates within age-group for each sex. The models included a term to adjust for age within each 20-year age-group. Effect modification of the mortality trend by age was tested for with a model including an interaction term for age-group by year comparing each adjacent 20-year age-group. The interaction term for the model comparing the 0-4 and 5-24 age-groups was the only comparison which was statistically significant, indicating that mortality trends were not the same in age-group 0-4 as in older age-groups. Additional analyses were therefore performed combining all age-groups except 0-4 (ie, for age-group 5+). Estimates of the percentage change in mortality rates between 1967 and 2000 were calculated from the estimate of average annual change in mortality rate produced by the regression model raised to the power of 33 (ie, the number of years in the period minus one).

Mortality rates presented in figures 7-8 were calculated separately for age-groups 0-4 and 5+ for seven five-year periods (by calendar year) from 1967-1971 to 1997-2000. The final period is of only four years because deaths data were not complete for the latter months of 2001 due to late registrations. Mortality rates for age-group 5+ were directly age-standardised using the age distribution of the 2001 NT Indigenous population as the standard population. Australian mortality rates were calculated in the same way from published deaths and

population data.[28] Age-standardised mortality rates for all age-groups combined were not calculated because mortality trends in age-group 0-4 were different to those in older age-groups, and the difference was statistically significant.

Rate ratios for NT Indigenous compared to total Australian mortality were estimated within the same five age-groups using a negative binomial regression model. Rate ratios were not calculated for all ages combined or for age-group 5+ because there was statistically significant evidence that rate ratios were not the same in each 20-year age-group.

Time trends in three broad cause-of-death groups were examined using the same broad groups as the Global Burden of Disease study: 1) communicable, maternal, perinatal and nutritional conditions, 2) non-communicable diseases and 3) injury.[29] Time trends for these groups were examined only from 1977—2000 because prior to 1977 an excessively high proportion of NT Indigenous deaths were coded as due to unknown or non-specific cause (18% for 1967-1971, 11% for 1972-1976, 7% and lower after 1977).

Sensitivity Analysis

The sensitivity of the results to inaccuracy in the two data sources (the number of Indigenous deaths and Indigenous population estimates for 2001) was tested by varying the number of deaths, the 2001 population estimates, or both by +/-10%. Stata Version 7 was used for statistical analysis.

3.5. Validation of population estimates

Population estimates produced by the back-casting method were compared with those produced by the NT Administration for 1966 and 1971, as were the number of births and number of deaths. Estimates were not compared to the census counts for those years as a validation measure because census counts are known to be a considerable, and variable, under-estimate of the population size.

Ethics approval

The project was approved by the joint Human Research Ethics Committee (HREC) of the Menzies School of Health Research and the NT Department of Health and Community Services (and by its Aboriginal Subcommittee) and by the Northern Territory University HREC. Use of unit record deaths data was approved by relevant state and territory Registrars-General.

4. Results

4.1. Number of deaths

The number of Indigenous deaths has increased only slightly from just under 400 in most years in the late 1960s to just over 400 per year in the late 1990s (Table 4). In age-group 0-4 years the number of NT Indigenous deaths per year fell considerably from 1967 to 2000, the majority of the fall occurring before 1981 (Figure 3); the Indigenous population in this age-group increased over this period. In contrast, the number of deaths per year in age-group 5+ almost doubled between 1967 and 2000, but did not increase at the same rate as the population in this age-group.

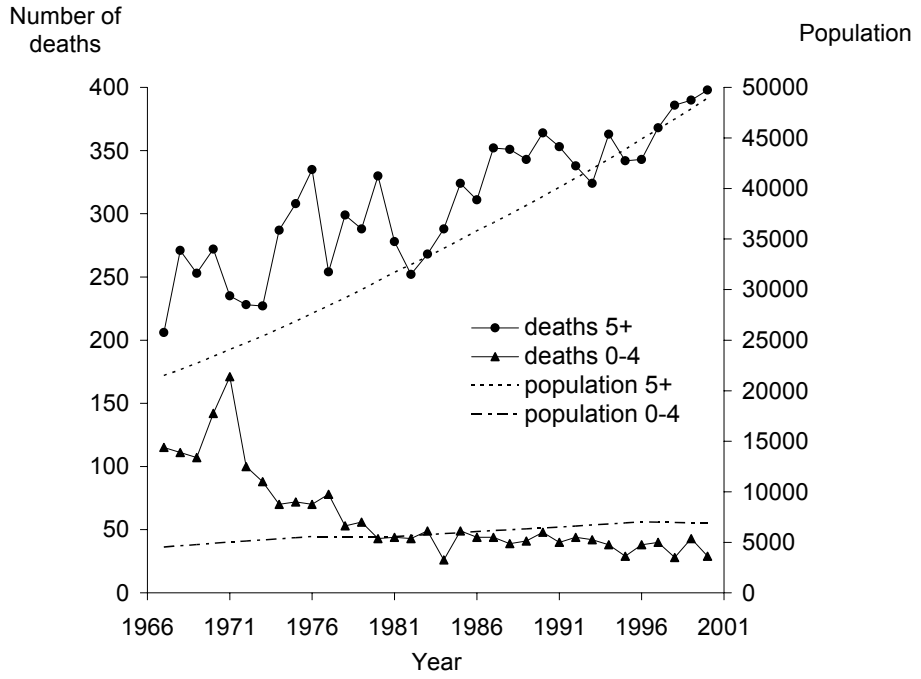

Figure 3 NT Indigenous deaths and population estimates[a], age-groups 0-4 and 5+, 1967—2000

a. back-cast population estimates, see Section 4.2

Table 4 Number of NT deaths by Indigenous status and sex, 1967—2000[a]

	Indigenous			non-Indigenous			
Year	Male	Female	Persons	Male	Female	Persons	NT Total
1967	164	157	321	120	38	158	479
1968	189	193	382	119	38	157	539
1969	214	146	360	110	46	156	516
1970	214	200	414	164	64	228	642
1971	220	186	406	179	59	238	644
1972	186	142	328	181	58	239	567
1973	180	135	315	188	58	246	561
1974	223	134	357	229	87	316	673
1975	225	155	380	191	68	259	639
1976	232	173	405	198	66	264	669
1977	201	131	332	179	51	230	562
1978	192	160	352	167	67	234	586
1979	195	149	344	202	76	278	622
1980	234	139	373	197	60	257	630
1981	201	121	322	202	79	281	603
1982	169	126	295	212	87	299	594
1983	169	148	317	209	77	286	603
1984	155	159	314	212	75	287	601
1985	214	159	373	210	88	298	671
1986	206	149	355	229	102	331	686
1987	242	154	396	271	105	376	772
1988	215	175	390	193	82	275	665
1989	221	163	384	245	109	354	738
1990	231	181	412	307	94	401	813
1991	199	194	393	268	109	377	770
1992	213	169	382	251	125	376	758
1993	207	159	366	270	117	387	753
1994	224	177	401	265	117	382	783
1995	218	153	371	294	142	436	807
1996	218	163	381	285	137	422	803
1997	216	192	408	278	140	418	826
1998	228	186	414	278	150	428	842
1999	247	186	433	278	138	416	849
2000	236	191	427	320	127	447	874

a. by year of death, not year of registration.

4.2. Population estimates

The back-cast method produced an internally consistent time-series from 1966 to 2001 (Table 5), which is in close agreement with the ABS Experimental Estimates for 1991-1996 (Figure 4). The back-cast population estimates for 1966 and 1971 were close to the estimates of the NT Administration for those years (1966: 25,345 c/w 24,120; 1971: 29,090 c/w 28,500) (Figure 4,Table 1).

The back-cast estimates are consistently greater than census counts, with the proportional increase being greater in earlier years (14%-40% in 1966—1986 compared to 12% in 1996 and 2001). NT census counts for Indigenous people by place of usual residence (produced from 1986 on) were almost identical to counts by place of enumeration (data not shown).

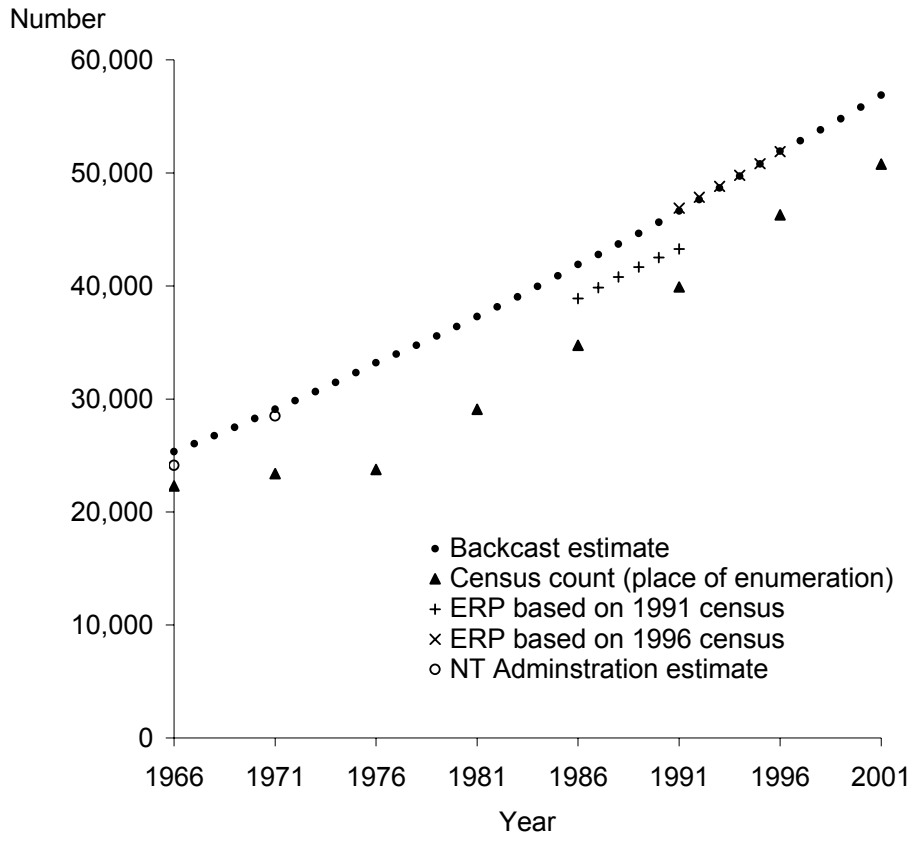

Figure 4 NT Indigenous population 1966-2001: census counts[a], ABS estimates[b] and backcast estimates

a. source: 6,30

b. source: 9,15

The Indigenous proportion of the NT population has previously been reported to be as low as 22% in 1986.[31] These previous reports were based on census counts, which provide misleadingly low estimates of the NT Indigenous population. In 1966 the estimated resident population of the NT was 56,504, of whom 45% (25,345) were Indigenous according to the back-cast estimates. Although the number of Indigenous people in the NT increased steadily between 1966 and 2001 (Table 5), the Indigenous proportion of the total NT population fell sharply to 34% in 1971 and to 27% in 1986 as the non-Indigenous population increased rapidly due to interstate migration, particularly to Darwin. However, the rate of increase in the total population slowed after 1986 and the Indigenous proportion of the NT population increased to 29% in 2001.

Extensive sensitivity analysis showed that the impact on population estimates of varying the source data was generally relatively small. Varying the 2001 population by ten percent changed the 1966 population estimate by six percent. Varying the number of deaths in each year by ten percent changed the 1966 population estimate by only four percent. Varying both together, in the same direction, changed the 1966 population estimate by ten percent. However, varying the two data sources had differing effects on 1966 population estimates in different age groups. For instance, varying the 2001 population by ten percent changed the 1966 population estimates by nine percent for age-group 0-4 but had no effect in age group 65+, while varying the number of deaths recorded in each year by ten percent changed the 1966 population estimates by only one percent in age-group 0-4 but by ten percent in age-group 65+.

Table 5 NT Indigenous population 1966-2001[a], backcast estimates

Sex and age group	1966	1971	1976	1981	1986	1991	1996	2001[b]
Male								
0-4	2,190	2,537	2,859	2,849	3,067	3,440	3,696	3,499
5-9	1,859	2,162	2,480	2,816	2,826	3,038	3,424	3,683
10-14	1,568	1,850	2,151	2,474	2,804	2,818	3,027	3,417
15-19	1,276	1,557	1,835	2,130	2,459	2,780	2,802	3,007
20-24	1,020	1,252	1,531	1,786	2,103	2,413	2,733	2,758
25-29	945	999	1,215	1,496	1,737	2,056	2,351	2,669
30-34	712	916	971	1,166	1,437	1,673	1,972	2,274
35-39	698	681	869	905	1,116	1,371	1,609	1,895
40-44	578	659	626	798	851	1,050	1,297	1,500
45-49	535	530	580	572	735	777	973	1,194
50-54	374	489	455	511	511	636	680	872
55-59	324	315	395	370	430	417	553	593
60-64	248	277	249	316	281	336	330	463
65-69	277	197	225	185	238	206	252	262
70-74	182	178	131	162	139	162	152	177
75-79	78	99	104	82	109	92	121	90
80-84	16	40	46	51	54	53	52	76
85+	15	14	27	27	34	49	50	63
Total Male	12,895	14,752	16,749	18,696	20,931	23,367	26,074	28,492
Female								
0-4	2,241	2,494	2,719	2,722	3,006	3,078	3,329	3,370
5-9	1,791	2,196	2,448	2,690	2,699	2,989	3,070	3,314
10-14	1,524	1,782	2,191	2,442	2,681	2,692	2,983	3,066
15-19	1,218	1,516	1,775	2,178	2,430	2,670	2,685	2,966
20-24	898	1,191	1,505	1,758	2,162	2,406	2,657	2,664
25-29	838	886	1,178	1,484	1,737	2,127	2,382	2,644
30-34	737	820	872	1,156	1,452	1,709	2,095	2,342
35-39	681	711	792	848	1,123	1,407	1,667	2,039
40-44	580	643	679	758	821	1,083	1,351	1,605
45-49	540	531	601	646	716	766	1,028	1,276
50-54	389	504	470	552	609	669	706	954
55-59	339	333	452	419	496	551	614	644
60-64	225	274	286	383	354	399	461	550
65-69	236	180	208	226	306	274	312	377
70-74	117	161	122	161	161	227	209	236
75-79	60	69	109	77	108	111	155	143
80-84	26	32	38	59	53	66	72	103
85+	10	15	24	34	45	51	72	90
Total Female	12,450	14,338	16,469	18,593	20,959	23,275	25,848	28,383
Total (M & F)	25,345	29,090	33,218	37,289	41,890	46,642	51,922	56,875
Change p.a. (%)[c]		2.8	2.7	2.3	2.3	2.1	2.1	1.8

a. estimates for 30 June

b. ABS Indigenous population estimates [25]

c. annual percentage increase in total population over previous five years

4.3. Age distribution

The estimated age distribution of the Indigenous population has changed considerably since 1966 (Figure 5). While the NT Indigenous population in 2001 was still a very young population compared to the total Australian population, the proportion of the Indigenous population aged 0-9 years decreased from 32% in 1966 to 24% in 2001, while the proportion aged 20-39 years increased from 26% to 34%. In 2001, the number in the youngest age-group (0-4 years) was similar to the number in the next age-group (5-9 years). However, the proportion of people aged over 65 years decreased from 4% to 3%. Although the total Indigenous population increased by 123% between 1966 and 2001, there was only a 58% increase in the number of people aged over 65 years, from 1,022 to 1,617.

The age distribution was relatively insensitive to variation in the 2001 population estimates and number of deaths. Varying source data by ten percent resulted in variation of less than one percentage point in the proportion of the population in any twenty-year age-group in 1966.

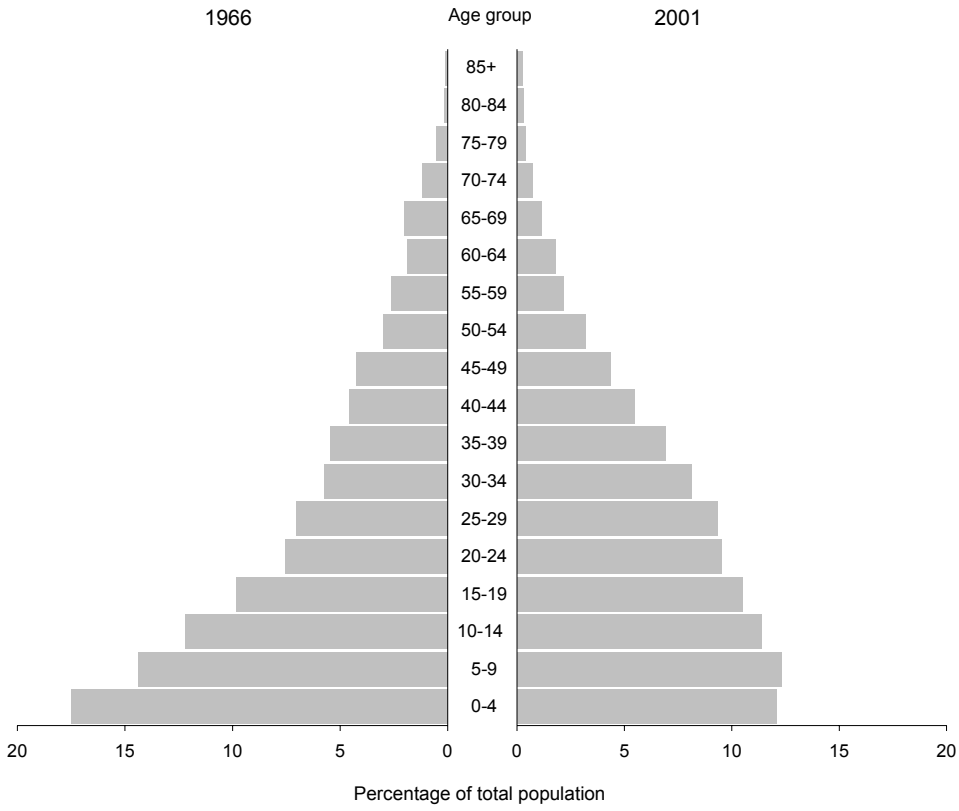

Figure 5 Age distribution, NT Indigenous population 1966 & 2001

4.4. Fertility

The estimated General Fertility Rate (GFR) for the NT Indigenous population declined steadily between 1966 and 2001, from 191 births per 1,000 women aged 15-49 in the period 1966-1971 to 96 per 1,000 in 1996-2001, a decrease of 50% (Figure 6, Table 6). This decrease was greater than that for the total Australian population, for which the age-standardised GFR decreased by 38% (from 90 to 56) (Figure 6). The GFR decreased by a similar proportion for the NT Indigenous (25%) and total Australian (28%) populations between 1966-71 and 1976-81, but thereafter decreased more for the NT Indigenous population (33% c/w 14%).

The NT Indigenous GFR was minimally sensitive to inaccuracy in 2001 population estimates and deaths data. Variation in the 2001 population estimate and number of deaths by ten percent resulted in less than one percent variation in the GFR for 1996-2001 and less than two percent variation for 1966-1971.

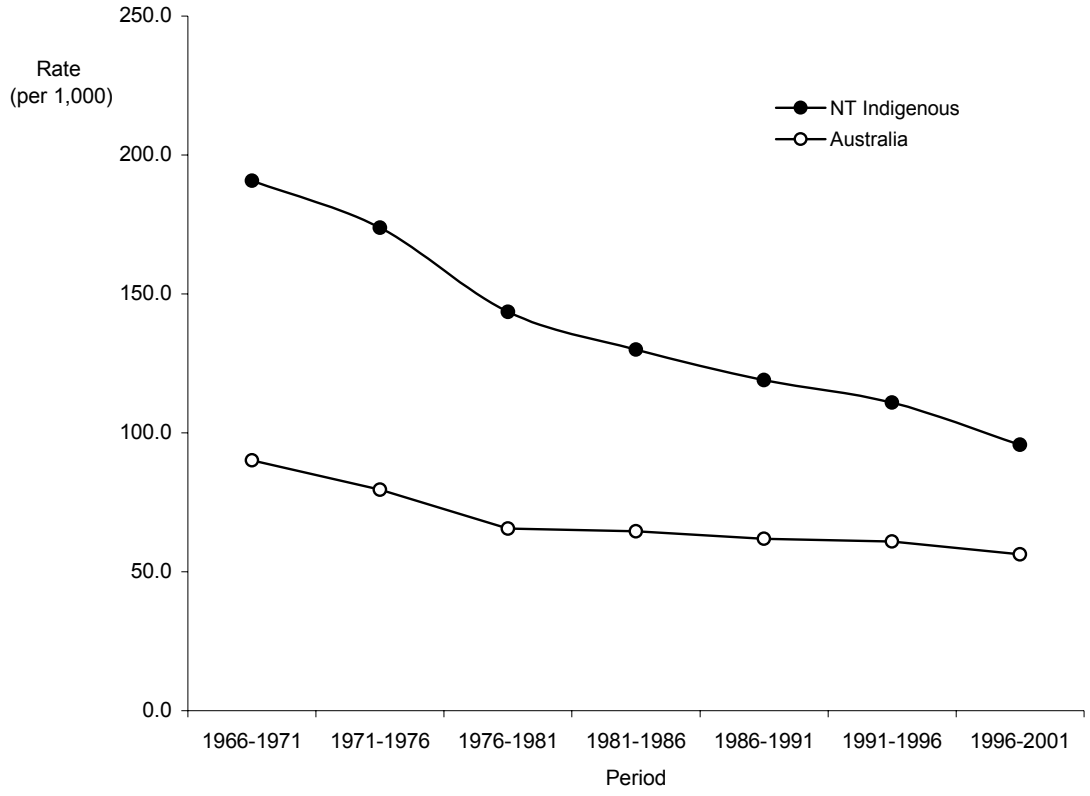

Figure 6 General fertility rate, NT Indigenous and total Australia[a]

a. standardised to NT Indigenous population distribution [97]

Table 6 Estimated NT Indigenous general fertility rate, five-year periods 1966-2001

Period[a]	Births[b]	Female 15-49[c]	GFR[d]
1966-1971	5,610	29,407	191
1971-1976	5937	34162	174
1976-1981	5808	40462	144
1981-1986	6242	48047	130
1986-1991	6711	56400	119
1991-1996	7200	64960	111
1996-2001	7022	73400	96

a. five-year periods from 1 July to 30 June

b. number of births as estimated by backcast population estimation

c. estimated number of person-years of females aged 15-49 years in each five-year period

d. General Fertility Rate (number of births divided by number of person-years of females aged 15-49, per 1000)

4.5. Mortality

NT Indigenous mortality rates declined in all age-groups between 1967 and 2000 (Table 7). The decline of approximately 85% for both males and females in age-group 0-4 years was much greater than for any other age-group. Mortality decline in 0-4 year olds occurred at a faster rate between 1967 and 1981 than in subsequent years (9.3% pa c/w 3.6% pa, for males and females combined) (Figure 7). This was not the case for older age-groups (Figure 8, Figure 9).

The age-standardised mortality rate for all age-groups combined (excluding 0-4 years) declined more for females than males (30% c/w 19%) and this difference was statistically significant (p=0.04). For females, the mortality decline was greater in age-group 5-24 than in older age-groups, but the number of deaths in age-group 5-24 was small and this difference was not statistically significant. For males in age-groups between 5 and 64 years mortality declines were not statistically significant in individual age-groups, but when the three age-groups were combined the decline of 12.5% over 33 years was statistically significant (p=0.04), but still considerably less than the decline in the oldest age-group. The absolute decline in NT Indigenous mortality rates between 1967 and 2000, as calculated from the regression model trend estimates (Figure 8), was slightly less than the decline in total Australian rates for males (3.3 c/w 4.1 per 1,000), but greater for females (4.1 c/w 2.2).

Table 7 Estimated decrease (% and 95%CI) in NT Indigenous mortality rates between 1967 and 2000, by age-group

Age group	Male	Female
0-4	85 (80,89)	84 (78,89)
5-24	22 (-4,42)	46 (20,64)
25-44	12 (-5,26)	27 (10,41)
45-64	14 (-2,27)	25 (12,37)
65+	31 (17,43)	29 (15,41)
5+	19 (9,27)	30 (22,38)

a. estimated decrease over 33 years, calculated from average annual rate of decrease as estimated by negative binomial regression model

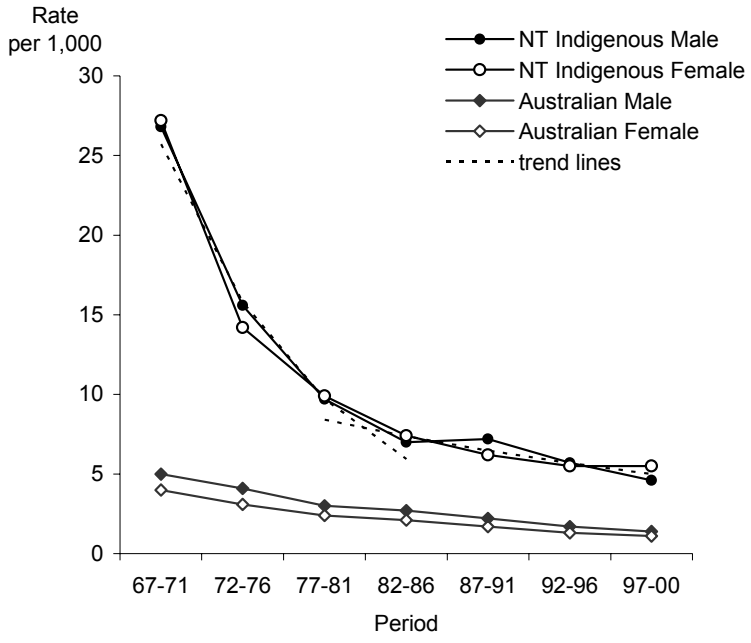

Figure 7 Mortality trends[a] for 0-4 year olds, 1967-2000

a. trend lines for male and female combined; separate trend lines for 1967—1986 and 1982—2000

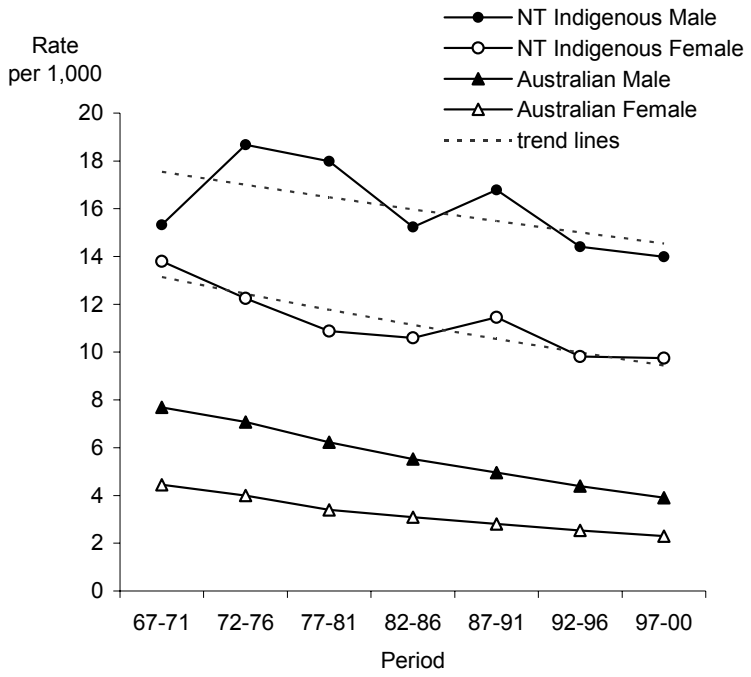

Figure 8 Age-standardised mortality rates (excluding 0-4 years), NT Indigenous and total Australia, 1967—2000

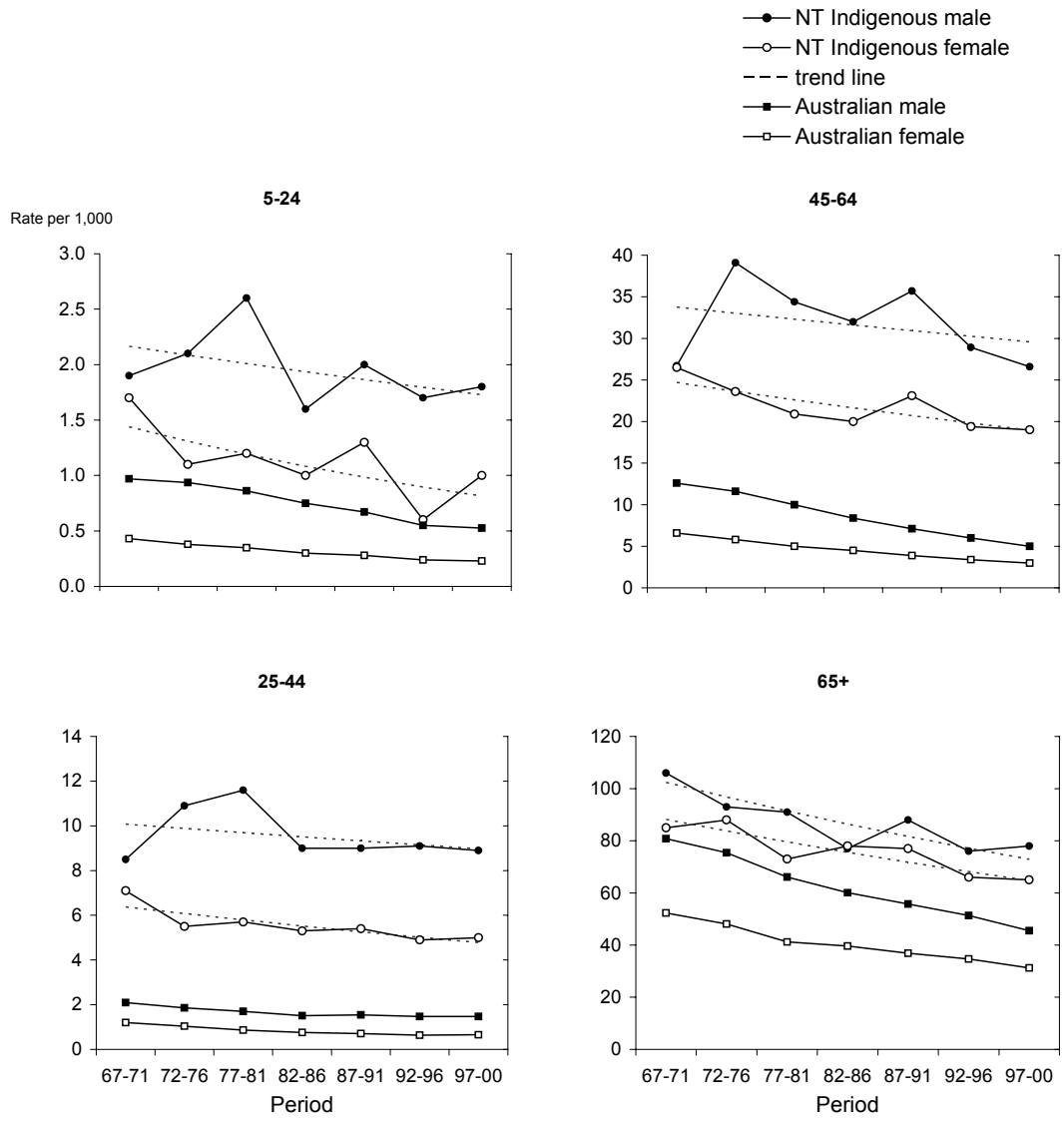

Figure 9 NT Indigenous compared to total Australian [a] mortality rates 1967-2000, age-specific rates and trend estimates

a. data source: [28]

NT Indigenous mortality rates were higher than total Australian rates for all age-groups in 1967-1971 (Table 8). While NT Indigenous mortality did decline between 1967 and 2000, the decline for the total Australia population was relatively greater so that the disparity between the two increased. Between 1967-1971 and 1997-2000 this disparity decreased only for age-group 0-4 years. The disparity was smallest, and increased only marginally, for the oldest age-group. The disparity increased markedly in the early to middle adult years and was greatest in these age-groups in 1997-2000.

Table 8 Mortality rate ratio[a] (NT Indigenous to total Australia), by age-group and sex, 1967—1971 and 1997—2000

	1967-1971	1997-2000
Male		
0-4	5.3 (4.7,6.0)	3.3 (2.6,4.2)
5-24	2.0 (1.5,2.7)	3.3 (2.5,4.4)
25-44	4.0 (2.3,4.8)	6.0 (5.3,6.8)
45-64	2.1 (1.7,2.4)	5.3 (4.7,6.0)
65+	1.4 (1.3,1.6)	1.6 (1.4,1.9)
Female		
0-4	6.9 (6.2,7.7)	4.9 (3.9,6.2)
5-24	3.8 (2.8,5.2)	4.3 (3.1,5.9)
25-44	6.0 (4.9,7.2)	7.7 (6.6,9.0)
45-64	4.0 (3.5,4.5)	6.2 (5.5,7.1)
65+	1.9 (1.6,2.2)	2.2 (1.8,2.8)

a. rate ratio and 95% confidence interval, estimated by negative binomial regression model, adjusted for age.

Between 1977 and 2000 the NT Indigenous mortality rate for ages 5+ for communicable, maternal, perinatal and nutritional conditions and for injury fell substantially (Table 9). However, the mortality rate for non-communicable diseases did not fall, the trend estimate indicating a slight increase which was not statistically significant.

Table 9 NT Indigenous mortality trend by broad cause of death category, percentage change between 1977 and 2000, age-group 5+, male and female combined.

	change in mortality rate[a]	Number of deaths (%)	
Cause of death category	% (95% CI)	1977-1981	1997-2000
Communicable etc.	-62 (-70,-52)	414 (24)	178 (11)
Non-communicable	5 (-4,15)	913 (53)	1202 (71)
Injury	-33 (-45,-19)	275 (16)	253 (15)
Other causes[b]	-85 (-90,-76)	121 (7)	49 (3)

a. percentage change in mortality rate calculated from the average annual change in mortality rate estimated by negative binomial regression model

b. predominantly non-specific or unknown cause of death

Sensitivity analysis

Mortality trends were unchanged when the 2001 Indigenous population estimates and the number of Indigenous deaths each year were both increased by ten percent (Table 10). Mortality trends were altered to a small extent when one data source alone was varied. Larger changes in mortality trends occurred when data sources were changed at the same time but in opposite directions (ie, one was increased by 10% when the other was decreased). The only scenario under which the mortality trend for age-group 5+ was reduced and was no longer statistically significant was when the number of deaths was increased by 10% at the same time as the 2001 Indigenous population estimates were decreased by 10%, which corresponds to the deaths data used here under-estimating actual deaths and the population estimates over-estimating actual population size.

Mortality trends were relatively insensitive to inaccuracy in source data in younger age-groups but were more sensitive in older age-groups when the source data were varied in opposite directions. In age-group 0-4 years, varying either the 2001 population or deaths data by ten percent changed mortality rates by approximately ten percent for both 1966 and 2001, so that there was almost no effect on mortality trends. Varying both data sources together caused no change in mortality rates or trends. Varying them by ten percent in opposite directions produced change in mortality rates of approximately 20% in the same direction in both 1966 and 2001, and thus minimal change in mortality trend.

In age-group 65+, varying 2001 population estimates or deaths data had no effect on mortality rates in 1966 but did change rates in 2001 by up to ten percent, and thus changed mortality trends to the same extent. Varying both data sources in the same direction did not change mortality trends, while varying them in opposite directions had no effect on mortality rates in 1966 but changed rates in 2001 by approximately 20% with a similar effect on mortality trends.

Table 10 Effect of variation (+/-10%) in source data on mortality trend [a] for age-group 5+

Data source variation [b]		Mortality trend after data source variation	
2001 IPE[c]	Indigenous deaths	Male	Female
		% change (95% CI)	% change (95% CI)
0%	0%	19 (9,27)	30 (22,38)
+10%	0%	24 (16,32)	35 (28,42)
0%	+10%	13 (3,23)	25 (16,33)
+10%	+10%	19 (10,28)	30 (21,38)
-10%	+10%	30 (22,37)	41 (34,47)
+10%	-10%	6 (-5,16)	18 (8,27)

a. percentage change in mortality rate estimated by negative binomial regression model adjusting for age.

b. positive variation indicates that source data was increased by 10% during sensitivity analysis, corresponding to a possible underestimation in the source data; negative variation corresponds to possible overestimation in source data

c. 2001 Indigenous population estimates

5. Discussion

Major changes have occurred in the demographic characteristics of the NT Indigenous population in recent decades. Both fertility and mortality have fallen. Mortality decline has been much greater in younger than older age-groups, but has nevertheless been substantial even in older age-groups. A demographic transition has commenced, but changes in the age distribution are concentrated in younger age-groups because the high mortality rates in the early and middle adult years have declined only slowly.

The time-series produced by the back-casting method is more accurate than census counts and is the only consistent long-term time-series of the Indigenous population available for any Australian state or territory. When compared to NT Administration estimates for 1966 and 1971 the back-cast time-series appears to be a reliable estimate of the size of the NT Indigenous population.

Limitations and sensitivity analysis

The potential limitations in this study arise from the data sources and the back-cast method used to produce population estimates. Firstly, net interstate migration is assumed to be zero for the Indigenous population. Although not conclusive, available evidence indicates that net interstate migration is very low for the NT Indigenous population (see Section 2.4), and this assumption is used by the ABS when calculating Indigenous population estimates. The impact of migration is likely to be small, although it may impact on some age groups more than others.

Secondly, Indigenous deaths may be under-identified in the deaths data. However, available evidence consistently indicates that identification of indigenous deaths is close to complete since 1988 when indigenous status was added to NT death notification forms (see Section 2.2). The inferral of indigenous status for deaths registered before 1988 in effect applies a consistent propensity to identify Indigenous deaths between 1967 and 1988, and has very high agreement with direct notification of indigenous status in death registrations after 1988. The inferral method is likely to have under-estimated the number of indigenous deaths prior to 1988 by a few percent (see Section 3.1); if that is the case, real declines in NT Indigenous mortality would be slightly greater than those reported here.

Indigenous status is also known to be of high accuracy in other health data collections in the NT, such as hospital separations data. In 1997 a direct validation study of Indigenous status recorded in NT public hospital separations data (by independent interview of inpatients) found that Indigenous status was correctly recorded in 94% of cases.[32]

Both the ABS assessment of completeness of indigenous identification in death registrations[8] and the inferral validation study[21] indicate that under-identification of Indigenous deaths is more likely than over-identification, but that the level of under-identification of Indigenous deaths is unlikely to be much higher than ten percent. As demonstrated by the sensitivity analysis, under-identification of Indigenous deaths by ten percent would result in the 1966 population being under-estimated by only four percent by the back-cast method.

Thirdly, the 2001 Indigenous population estimates may under-estimate the actual size of the NT Indigenous population, which would result in under-estimation of the back-cast population estimates; all available evidence indicates that the 2001 Indigenous population estimates are very unlikely to be over-estimates (see Section 2.1). However, NT Indigenous population estimates based on the 1996 and 2001 censuses are consistent,[9,25,33] the NT Indigenous population has had a very low propensity to change identification of indigenous status[6] and evidence that the 2001 population estimates are too low indicates that the degree of under-estimation is probably small.[13]

Fourthly, as noted above, the exact age of a high proportion of older Indigenous people in the NT is not known. This does not affect the back-cast estimates of the total population size nor sex distribution, but may affect the age distribution. The recorded approximate year of birth is most likely to be inaccurate for very old people from remote communities in Arnhem Land and the Western Desert who died in the 1960s and 1970s – these people may have had contact with government officials, missionaries or pastoralists for only one to three decades before their death. Large degrees of inaccuracy in age at death for these people would affect only the age distribution in the oldest age-groups in the population estimates for the 1960s and 1970s, and would have little effect on the proportion of people in broader age-groups such as the 20-year age-groups used here for mortality analysis.

The sensitivity analysis demonstrates that under-estimation by either data source (2001 population estimates or number of deaths) has only a moderate effect on the size of back-cast population estimates and little effect on age distribution, fertility measures or mortality rates. Varying one data source (2001 population estimates or number of deaths) but not the

other during the sensitivity analysis changed back-cast population estimates differently in younger and older age-groups. Population estimates for age-group 65+ in 1966 are based solely on the number of deaths between 1966 and 2001 because people in age-group 65+ in 1966 were all deceased by 2001. Population estimates for age-group 0-4 in 1966 are based predominantly on the estimates for age-group 35-39 in 2001 because only a small proportion of people in this birth cohort died before reaching 35-39 years of age in 2001. Variation of both data sources in the same direction changed 1966 population estimates by a similar amount in all age groups.

The most likely scenario for inaccuracy in source data is that indigenous deaths may be underestimated by a small extent, probably less than ten percent, and that if there is any inaccuracy in the 2001 population estimates it will also be a small underestimate. The sensitivity analysis indicates that inaccuracy in the two data sources in the same direction (ie, both under-estimates) has minimal effect on mortality rates or trends.

Comparison with other data sources

The back-cast estimates are in close agreement with the NT Administration estimates for 1966 and 1971. The NT Administration estimates have been reported to be the most reliable, and reasonably accurate, estimates of the Indigenous population at that time.[14] The close agreement between the back-cast estimates and the NT Administration estimates provides the most convincing evidence that the back-cast estimates are reliable.

The total number of Indigenous deaths estimated by inferral from death registrations for the period 1967—1971 was close to the number recorded for the 'Aboriginal tribal population' by the NT Administration at the time (1,883 c/w 1,843), although there was variation between the two sources in individual years (Table 2, Table 4). However, the 'Aboriginal tribal population' included only about 80-85% of the total Indigenous population at that time, suggesting that the inferred number of Indigenous deaths may have been an under-estimate for those years.

The back-cast method estimated that there were 5,610 Indigenous births in the period between 1 July 1966 and 30 June 1971, an average of 1,122 births per year (Table 6). The average number of births recorded for the 'Aboriginal tribal population' by the NT Administration for the years 1966-1971 was 790, 30% less than the estimate produced by the back-casting method (Table 2); most of this difference is due to the 'Aboriginal tribal population' being 15-20% less than the entire Indigenous population. The crude birth rate

estimated the period 1 July 1966 to 30 June 1971 from back-cast birth and population estimates was 41 per 1,000, higher than the range of 37-39 per 1,000 estimated from the 'Aboriginal tribal population' for the years 1966 to 1971.[14] This is consistent with the higher estimate of Indigenous births produced by the back-cast method.

The number of Indigenous births estimated by the back-cast method could also be compared to the number of Indigenous births registered after 1988, when indigenous status was added to birth notification forms. Assessment by the ABS of accuracy of indigenous status recorded in NT birth registrations between 1988 and 2001 indicates that the number of Indigenous birth registrations was incomplete by several percent. In addition, published data on Indigenous births are for births registered by calendar year, while the back-cast method estimates births that occurred in five-year periods from 1 July to 30 June, so any comparisons would be approximate at best. The number of Indigenous births estimated by the back-cast method for 1 July 1991 to 30 June 1996 was 9% higher than the number registered between 1 January 1991 and 31 December 1995, but at least part of this difference is due to incomplete identification of Indigenous births.

Application to other Indigenous Australian populations

The back-casting method cannot be used to produce Indigenous population estimates for states and territories other than the NT because of the unreliability of recent population estimates and the lack of accurate Indigenous deaths data. In other Australian states recent census counts and population estimates are not yet sufficiently stable from one census to the next to form a reliable basis from which to commence.[6,25] The inferral method of identifying Indigenous people in death registrations is unlikely to be reliable in other states because Indigenous people comprise only 2-4% of the total population and many Indigenous people no longer have names in distinctive Indigenous languages nor live in geographically discrete Indigenous communities.

However, it may be possible to extend this method to rural and remote areas of several states where Indigenous people make up a considerable proportion of the population and can be more reliably identified. The ABS produces experimental estimates for the population of each of the 36 ATSIC Regions. The back-casting method could possibly be applied to groupings of several such regions in northern Queensland and northern Western Australia. If net migration into/out of these areas is close to zero it may be possible to examine long-term demographic trends of Indigenous people, particularly by combining regions rather than undertaking separate analyses within individual states.

Demographic changes

The potential inaccuracies in data sources considered above would change the results reported here by only a relatively minor degree compared to the magnitude of trends observed in the demographic characteristics of the NT Indigenous population over the past four decades. The age-distribution of the NT Indigenous population is steadily becoming 'older'. The proportion of the population in the youngest age groups (0-9 years) is falling and that in early adulthood (20-39 years) is rising. However, the proportion of the population aged over 65 years declined slightly between 1966 and 2001.

The General Fertility Rate for the NT Indigenous population in 1996-2001 was less than half what it had been in 1966-1971, a greater decrease than occurred for the total Australian population. This is consistent with reports of declining fertility for the total Indigenous Australian population since 1970 and for the NT Indigenous fertility since 1988. [4,5]

Indigenous children could be born to both Indigenous women (regardless of whether the father was also Indigenous) and to non-Indigenous women (when the father was Indigenous). Although the GFR for Indigenous women should be calculated by excluding Indigenous births to non-Indigenous mothers from the numerator, no data on the proportion of Indigenous births to non-Indigenous mothers are available for most of the time period considered here. There are indirect indications that the proportion of Indigenous births to non-Indigenous mothers in the NT is low, and is increasing only slowly. In the 1966 census only 15% of Indigenous people in the NT reported being of 'mixed decent'; the same data was not collected in subsequent censuses. In each census between 1986 and 1996 approximately 20% of mixed-sex couples with at least one Indigenous partner had one non-Indigenous partner; that is, in approximately 80% of Indigenous couples both partners were Indigenous. This is a much higher proportion than in other states and territories.[6]

Correction of the GFR for the proportion of Indigenous children born to non-Indigenous mothers would decrease the GFR estimates. If, as seems likely, this proportion increased between 1966 and 2001, the corrected GFR for 1996—2001 would be reduced by a relatively greater extent than that for 1966—1971. The uncorrected decrease in GFR reported here would thus be an under-estimate of the actual decrease.

Part of the decline in the Indigenous GFR may be due to a change in the age distribution of women within the age range from 15 to 44 years. NT Indigenous age-specific fertility rates are highest in the age-groups 15-19 and 20-24 and fall rapidly in older age groups.[4] The estimated number of NT Indigenous women aged 15-24, as a proportion of the total number of women aged 15-44, fell from 43% to 39% between 1966 and 2001 while the proportion in age-group 25-34 increased from 32% to 35%. The proportion aged 35-44 remained constant at 26%. This small shift from the 15-24 age-group to the 25-34 age-group would contribute only to a small extent to the fall in the GFR.

The fertility decline found here is consistent with the increasing number of terminations of pregnancy that are occurring for Indigenous women in the NT. Between 1976 and 1986 the number of terminations was approximately one percent of the number of live births for Indigenous women (compared to approximately 20% for non-Indigenous women in the NT); by 1995 this had risen to nine percent for Indigenous women.[34,35] No information is available on the use of other methods of contraception in the NT Indigenous population.

Mortality trends

While the very large fall in infant mortality since the late 1960s has been previously described,[4] reports of NT Indigenous mortality rates during the 1980s and early 1990s have not indicated that mortality rates were falling in the early and middle adult years.[11,21] There has been great concern about the rise of chronic disease in the early and middle adult years, with indications that the overall health status of Indigenous adults is not improving.[36]

This report demonstrates that Indigenous mortality has declined over the past four decades in the NT, and has declined in all age-groups, providing some encouragement about the health status of Indigenous people in the NT. There has been considerable improvement in female mortality rates in all age-groups. The trend in male mortality is also downward, although not to the same extent as for females and the decline has been minimal for males in the early and middle adult years. Although Indigenous mortality rates have been declining, the rate of decline has been even greater for the total Australian population, so that, with the exception of age-group 0-4 years, the relative disparity been NT Indigenous and other Australians has increased since 1967.

Conclusion

This work demonstrates for the first time the extent of demographic changes that have occurred in part of the Australian Indigenous population over the past four decades. A demographic transition from a young population with high fertility and mortality appears to have commenced in the late 1960s.[5,14] If the much lower fertility levels of recent years are maintained, the age distribution of the NT Indigenous population will over the next two to three decades become 'older', more like a developed than developing country. This trend is assisted by the decline in mortality rates in childhood and the teenage years. If fertility and child/teen mortality continue to fall, the age distribution will develop the 'bulge' seen in the total Australian population described as the 'baby boomer' generation. This would also continue the decline in the growth rate of the NT Indigenous population, which fell from 2.8% per annum in 1966—1971 to 1.8% per annum in 1996—2001. However, in the future other factors such as an increasing proportion of mixed Indigenous and non-Indigenous couples are likely to become a greater influence on the demographic characteristics of the NT Indigenous population, as has already occurred in other states.[6] This may slow or even reverse the decline in population growth rate.

The most encouraging trend reported here is the long-term decline in Indigenous mortality rates, indicating that improvements in Indigenous health status have occurred in all age-groups and both sexes over the past 35 years. However, the relative differential between Indigenous and non-Indigenous mortality rates has not decreased, and even greater efforts by both Indigenous and non-Indigenous Australians to improve the social, environmental, economic and educational status of Indigenous Australians are needed to eliminate the gaps in health status, and overall social condition, between Indigenous and other Australians.

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