



**Australian Government**

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# **Comparing life expectancy of indigenous people in Australia, New Zealand, Canada and the United States**

**Conceptual, methodological and data issues**

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Australian Institute of Health and Welfare  
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# Abbreviations

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
AU	Australia
AI/AN	American Indian and Alaska Native
CA	Canada
IHS	Indian Health Service
INAC	Indian and Northern Affairs Canada
NCHS	National Center for Health Statistics
NZ	New Zealand
SVS	Status Verification System
UN	United Nations
UNDP	United Nations Development Programme
USA	United States of America

# Summary

Numerous studies have estimated that the gap between indigenous and non-indigenous people's life expectancy in Australia is greater than in New Zealand, Canada and the United States of America (USA).

- It is now widely believed that Indigenous Australians experience lower life expectancy than their counterparts in comparable countries.
- While this may be true, there are many technical difficulties involved in estimating and comparing indigenous life expectancies. Difficulties related to concepts, data and methods behind such estimates throw doubt on conclusions drawn from country comparison studies.

Australia, New Zealand, Canada, and the USA differ in how they define indigenous, their method of operationalising the definitions, and how they adjust the death and population statistics to allow for known problems.

- New Zealand, Australia, and the USA have adopted an 'inclusive' definition of indigenous; but death data are not of sufficient quality to calculate life tables in several Australian states, or in the USA as a whole. Instead the USA calculates life expectancy from data derived from the Indian Health Service.
- Canada recognises several indigenous subgroups, but they are not identified in the full Census or in the death statistics system, and special studies are used to estimate the life expectancy of some of these groups.

In general, cross-country comparisons give little or no consideration to the level of uncertainty associated with the data and methodologies used.

- Most publications present and discuss differences between country estimates of indigenous life expectancy as though they represent real differences.
- Only a few publications provide general cautions about drawing conclusions in the presence of uncertainties of largely unknown magnitude.

In the absence of direct information about estimation errors and uncertainties, this paper provides an informed evaluation of their magnitude.

- This analysis indicates that the overall uncertainty caused by conceptual, data and methodological issues could be quite large.
- Consequently, it is difficult to justify drawing many conclusions regarding cross-country differences.

Improving the reliability of comparisons would involve all countries moving towards an 'inclusive' definition, and developing robust methods to test and adjust the population and death data for inadequate reporting.

- In New Zealand, Australia and the USA, only incremental change would be required: existing census and death data systems could be strengthened, and new validation and adjustment methods developed.
- In Canada, by contrast, major system changes would be required to obtain national data on the population and deaths of all the indigenous subgroups.

The International Group for Indigenous Health Measurement is an expert international working group in the field of indigenous health. With sufficient political backing, this group

is appropriately placed to spearhead a coordinated international effort to overcome the barriers currently presented by the disparity between countries in concepts, data and methods underpinning indigenous life expectancy estimates.



# Introduction

Over the past 20 years, various studies have compared Australian Indigenous life expectancy, and the life expectancy gap between Indigenous and non-Indigenous Australians, with that of indigenous people in the other Anglo-settler countries of New Zealand, Canada and the United States of America (USA). Without exception, life expectancy of Indigenous Australians has been found to be lower, and the gap greater. But there are many technical difficulties in estimating Indigenous life expectancy. In Australia, each method revision has reduced the estimated disadvantage of Indigenous Australians, nationally and internationally, to the extent that a paper by Hill and others (2007) asked whether Indigenous Australians really are more severely disadvantaged than the other indigenous populations.

International comparisons of health indicators are always problematic, and comparisons of indigenous health are especially so. For national populations, the United Nations, World Health Organization, European Union, Organisation for Economic Co-operation and Development, International Agency for Research on Cancer, and others have put great effort into obtaining internationally comparable statistics on: the incidence and causes of death; the incidence, prevalence and morphology of cancer; the incidence and causes of hospitalisation; and to a lesser extent survey-based data on health status and risk factors. Yet differences in health systems, social and economic circumstances, medical culture and population attitudes mean that all international comparisons remain heavily qualified. Add to this the impact of colonisation, racism, discrimination, treaty rights and statistical ambiguity on available statistics of indigenous health and populations at risk, and it is not surprising that comparisons of indigenous health between countries pose such a challenge.

Most published commentary on international comparisons has focused on contrasting indigenous life expectancy, presumably because of its apparent lack of ambiguity. Yet these comparisons remain problematic for several reasons, including:

- the definition of who is indigenous differs between countries and over time
- the determination and measurement of indigenous deaths and the indigenous population at risk vary between countries, and are often not consistently applied within countries or over time
- the methods used to adjust for inadequate measurement of the populations and/or deaths vary
- the definition and determination of indigenous deaths and the population at risk vary within countries.

Yet it is evident from the number of comparative studies published, and from the attention they receive, that there is a strong professional, political and popular interest in how the countries compare. To understand how they compare, we need to understand the complexities of history, definition, data collection and estimation method involved.

This study tries to describe the methodological dimensions and differences involved in deriving estimates of indigenous populations and deaths, and, from them, life expectancy in the four Anglo-settler countries. The differences in indigenous life expectancy estimates that have been presented in comparative analyses between the four Anglo-settler countries are also described to establish the level of confidence with which conclusions may be drawn. A short concluding section discusses possible ways forward.

# Life expectancy estimation methods used for indigenous populations

Despite their common backgrounds as British colonies, there are fundamental differences in the way in which the four countries recognise and conceptualise their contemporary indigenous populations, both in general policy terms and specifically for statistical purposes.

It is important to note that in this study, the focus is on indigenous identification in statistical systems. In the context of large increases in census counts of Indigenous Australians, Gardiner and Bourke (2000) pointed to 'under-theorised' commentary on Indigenous statistics, which had confused marking a box on a census form with Indigenous identity, to the extent of suggesting that identity is as fluid, contextual, changeable, ambiguous and problematic as the census counts. In both Australia and New Zealand, development of Indigenous statistics has been overwhelmingly determined by technical and bureaucratic considerations.

In Australia, official statistics for the past four decades have taken an inclusive approach based on self-identification, recognising statistically only the difference between mainland Aborigines and Torres Strait Islanders.

Despite a much longer-standing recognition of prior rights, New Zealand has only recently adopted a similarly inclusive statistical approach, and it uses a different method to identify indigenous people in statistical collections.

The USA has also used an inclusive approach in death registrations and population statistics for four decades, although the widely used Indian Health Service (IHS) statistics are based only on people on or near reservations. By contrast, in Canada, where the policy and statistics focus has been on indigenous people with treaty rights, information on other groups is fragmented, and statistics on the entire population of indigenous descent are not available.

In addition to these public policy and race relations differences, the countries differ in the extent to which they have succeeded in operationalising their concept of indigenous for statistical purposes. In Australia, for instance, it has been necessary to develop adjustment methods to compensate for substantial deficiencies in the enumeration of the Indigenous population and the identification of Indigenous deaths. In the USA, as in Australia, there are problems with the identification of indigenous deaths by funeral directors, and with identifying Status (or Registered) Indians and their deaths if they do not live on reservations. In Canada, there is no identification of Aboriginal deaths in the national death statistics system, and race is only obtained from a 20% sample at the Census. A recent decision that participation in the 20% sample will, in future, be voluntary will further reduce the adequacy of national Aboriginal population estimates.

In the following sections the main methods that have been used in each country over the past 20 years to estimate indigenous life expectancy are reviewed. These are also summarised in the appendix tables. There is a focus on official estimates from each country in the first instance, then on attempts that have been made to improve official estimates by, for example, mortality follow-up studies. In the final section the various attempts that have been made to compare the life expectancy estimates between countries are reviewed.

## Australian estimates

Australian estimates of Indigenous mortality and life expectancy, and of the gap between Indigenous and non-Indigenous Australians, have had to deal with three problems.

- Non-reporting / incorrect reporting of Indigenous deaths in the national mortality database, which varies by demographic and geographic grouping and over time.
- Uncertainty about the size of the Indigenous population, and changes in the estimated size resulting from changed census procedures and changed responses to the Census, again apparently varying by demography and geography.
- Uncertainty about the extent of numerator/denominator bias (that is, the extent to which the classification of Indigenous deaths (numerator) and population (denominator) occur in a consistent manner).

## Australian Bureau of Statistics estimates

In the past 20 years, the Australian Bureau of Statistics (ABS) has produced four sets of estimates based on four different methods. Drawing on the results of the 1991, 1996, 2001 and 2006 censuses, the ABS has adjusted the population estimates to account for non-enumeration and non-response to the Indigenous origin question in censuses, and has adjusted the recorded numbers of Indigenous deaths to make them compatible with the population estimates. The methods used to adjust the population were different at each Census, as the ABS refined their attempts to come to terms with unexplained changes between censuses and known errors and biases in enumeration and recording of deaths. In addition, after each Census, the adjusted Indigenous population was backcast to the dates of the earlier censuses, in an attempt to obtain a consistent time series.

The method used to adjust the deaths varied at each Census. After the 1991 Census, the ABS restricted its analysis to those states and territories considered to have adequate reporting (Anderson et al. 1996). After the 1996 Census, they used Preston and Hill's 1980 adaptation of the sectional growth balance method, which assumes that the population is closed between censuses. Since that was known not to be the case, the earlier population was adjusted, in an attempt to remove unexplained change – a somewhat circular procedure. After the 2001 Census, the ABS adopted Bhat's 2002 modification of the growth balance method, which takes into account migration between the censuses, to allow for unexplained change. This method requires the age distribution of unexplained change to be estimated from census survival ratios, and the true rate of growth to be known, which again introduced an element of circularity.

A major change occurred after the 2006 Census, when the ABS abandoned indirect methods, and instead corrected registered deaths in advance of calculating death rates and life tables by the standard direct method from the adjusted or corrected figures. This study linked death records for an 11-month period to the 2006 Census records, which enabled comparisons of the reporting of Indigenous status. Indigenous identification rates were computed by dividing the number of registered deaths reported as Indigenous by the expected number of Census Indigenous deaths. The resultant identification rates were used to derive factors for adjusting registered deaths. The adjusted deaths were then used to compile Indigenous life tables (ABS 2009).

Over the period in question, it appears that, while Indigenous enumeration did not consistently improve (and in some cases may have deteriorated), the ABS developed much

better methods to identify and correct deficiencies in the enumeration. At the same time, the identification of Indigenous deaths improved greatly, although remaining deficient in some parts of the country (mainly large cities).

The net effect of all these changes was to see the officially estimated national gap reduced from 19 years in 1991–1996 to 14 years in 2001–2006. A key question, and one that has generated much controversy, is the extent to which these changes reflected:

- real changes in life expectancy
- changes in the methods
- changes in the adequacy of the death or population statistics
- changes in the adequacy of coverage of different social, demographic or geographical subgroups of the population.

To some extent these questions may be answered by looking at the range of estimates produced by others outside the ABS.

### **Other Australian estimates of life expectancy**

Like the ABS estimates, unofficial estimates must take account of the problems of incomplete identification of deaths, uncertainty of population size, and numerator/denominator compatibility and appropriateness. As with the ABS, two approaches have been taken – indirect estimation using different variations of the sectional growth balance method, and direct estimation after correction for missing deaths and population size.

Only three groups have produced estimates for Australia and the states and territories, but others have produced estimates for individual jurisdictions.

As part of a University of Queensland project to estimate the Indigenous burden of disease in Australia, Hill, the developer of the generalised growth balance method (1987), was commissioned to produce new estimates of Indigenous mortality and life expectancy (Hill et al. 2007). Hill and his colleagues used the census counts rather than the ABS adjusted populations, arguing that the growth balance corrections would allow for under-enumeration, lack of closure and unexplained change between censuses. The growth balance method is based on the assumption that populations and deaths missed have the same sex/age distribution as those included. Hill and others (2007) argued that various sensitivity analyses demonstrated that violation of these assumptions did not seriously bias the results. They obtained estimates of the gap in 1996–2001, which, while still large, were significantly lower than those the ABS had produced based on the 1996 and 2001 censuses using the modified Bhat method. However, their 1996–2001 estimates were reasonably close to those obtained by the ABS for 2005–2007 using post-Census mortality follow-up linkage.

Barnes and others (2008) compared the impact of violation of the growth balance assumptions on estimated life expectancy, using various estimates of population size and composition. In contrast to Hill and others, they found that violation of the assumptions – especially about the proportionality of missing populations – could produce extreme fluctuations in the estimates of life expectancy, and that direct calculation of life expectancy after including all available adjustments to both deaths and populations was a much more robust approach.

Most recently the AIHW (2010) used data linkage to complement the ABS National Mortality Database by extracting Indigenous identifiers from other information systems that identify Indigenous deaths, including hospital deaths, deaths in residential care, and perinatal

deaths. They explored various criteria for identifying a death as Indigenous, and found that this had little effect on the estimates. They used the ABS estimates of resident Indigenous populations. These investigators also obtained estimates of life expectancy that were reasonably close to the most recent ABS estimates, although they point out that their estimates of deaths are minimum figures, which would be expected to increase – and produce a lower life expectancy – if linkage were extended to other data sources.

Kinfu & Taylor (2002), in an investigation of the components of Indigenous population change between 1996 and 2001, used two variants of the growth balance method to estimate Indigenous life expectancy. Based on Preston & Hill (1980) they found life expectancies of 57 years for males and 65 years for females, representing gaps of 18.9 and 16.8 years, and implying little change in mortality since the previous census period. However, they preferred Hill's (1987) method, which estimated male life expectancy at 58.9 years and female at 65.1, and gaps of 17 and 16.7 years, respectively.

The true life expectancy of Indigenous Australians remains a matter of dispute. An analysis of the differences between states and territories reveals a worrying correlation between estimated life expectancy and the completeness of death reporting – the better the reporting, the lower the life expectancy (Barnes et al. 2008). The Northern Territory has had very good reporting on Indigenous identification on death records for many years, and, consequently, the Northern Territory Government has been able to estimate life expectancy for its Indigenous population using the direct method for several decades (see, for example, Li & Guthridge 2004). For recent years, the Northern Territory Government direct method estimates are similar to those obtained by all indirect methods and the linkage method, and are the lowest of any state or territory. However, this may itself reflect the fact that it is easier to obtain good Indigenous death data from the more readily definable Indigenous communities in rural and remote Australia, which have the worst health and lowest life expectancy.

By contrast, while Western Australia has also been considered to have reasonably complete reporting of Indigenous deaths, studies there have shown that linkage to the hospital, mental health and midwives collections resulted in an extra 6–8% of deaths of unknown status being identified as Indigenous, and life expectancy estimates being reduced by 1 to 2 years (Draper et al. 2009). Worryingly, it was also found that the quality of the death data in Western Australia had deteriorated significantly in more recent years, due to a reduction in follow-up action when the Indigenous information was not provided.

## **New Zealand estimates**

### **Statistics New Zealand life tables**

Statistics New Zealand is the source of official Maori life expectancy estimates. Each year, it publishes mortality rates and period (abridged) and cohort life tables for the population of New Zealand each year; every five years, to coincide with the population Census, it publishes complete period life tables separately for the Maori and non-Maori populations (Statistics New Zealand 2009). The period Maori life tables are based on recorded Maori deaths for the 3 years surrounding each five-yearly population Census, and census counts of the Maori population, after adjustment for deaths and census counts with no ethnic response. A long time series of Maori and non-Maori life tables is available on the Statistics New Zealand website starting from the period 1950–1952.

In reporting on the health of New Zealanders, the New Zealand Ministry of Health also uses Statistics New Zealand's Maori life tables.

## **New Zealand Census–Mortality Study life tables**

Another source of Maori mortality and life expectancy is the New Zealand Census–Mortality Study done by the Department of Public Health, Wellington School of Medicine and Health Sciences at the University of Otago. This study is designed to develop a data set for understanding mortality differentials between population groups, including Maori.

Working with Statistics New Zealand and the New Zealand Ministry of Health, the University of Otago completed a series of studies linking records from the 1981, 1986, 1991, 1996 and 2001 New Zealand censuses to death records in the 3 years following the censuses. The linkage was anonymous, based on the characteristics of the individual, and produced improved death records that contain socioeconomic characteristics from the Census, including Maori (and other ethnic group) status.

By comparing the raw death registration counts with the census-improved counts of Maori deaths, ratios were calculated to adjust for under- or over-identification of Maori deaths. Similar adjustment ratios can be calculated for deaths of other groups. These investigators have termed the process of adjustment 'unlocking the numerator-denominator bias' (Ajwani et al. 2003b). Adjusted death data can then be used to calculate mortality rates and life tables.

Life expectancies of Maori and non-Maori based on this work were jointly published by the University of Otago and the New Zealand Health Ministry as part of a report that documented ethnic differentials in health (Ajwani et al. 2003a). Statistics New Zealand used results of the 1996 New Zealand Census – Mortality Study to produce a revised set of 1995–1997 Maori life tables.

## **Population census data for New Zealand Maori**

A question on the ethnicity of the people of New Zealand has always been included in the New Zealand population Census. Before the 1986 Census, a question on the degree of blood (racial fraction) was included in censuses. In 1986, the question was changed to a question on the person's 'ethnic origin'. From 1991 onwards, respondents were asked what 'ethnic group' they belong to. Answer boxes, which included Maori, New Zealand European, various Pacific Islander groups, Chinese, Indian and others, were provided on the census forms as well as a write-in space for other ethnicities. Multiple answers were permitted, and statistics were available on 'single response' or 'total response' Maori. The Maori life tables published by Statistics New Zealand from 1990–1992 use 'total response' Maori population denominators.

Single response (or 'sole') Maori are those who chose the Maori answer box only. Total response Maori are those who identify as Maori with or without also identifying any other ethnicity. Thus a person who answered Maori as well as New Zealand European is included in the total response Maori group. So the total response Maori group includes all those who chose the Maori answer box, irrespective of whether or not they also chose another ethnicity.

The population denominator for New Zealand life tables is the estimated resident population. The estimated resident population of an area is the 'Census usual resident count' adjusted for net undercount at the Census. Visitors to the area are excluded. The estimated

resident population for the Maori population has an additional adjustment – those who did not answer the ethnicity questions were allocated to the Maori and non-Maori categories.

## **Death data for New Zealand Maori**

The New Zealand Department of Health routinely receives death data from the New Zealand Registry of Births, Deaths and Marriages for the compilation of vital statistics. Data on the ethnicity of the deceased are collected on the death registration form, which is normally filled in by funeral directors.

Before 1995, the death registration form asked for the degree of Maori and Pacific Island blood. Since 1995, the question was changed to a question similar to that used in the 1996 Census – that is, answer boxes are provided for Maori, New Zealand European and so on. Multiple answers are allowed. Maori deaths are those where the Maori answer box was chosen, irrespective of whether or not another ethnicity box was also chosen. Thus, the way Maori deaths are identified is nominally the same as that used to identify Maori people in the Census. Non-response to the ethnicity question on the death registration form has been less than 5%, and these were allocated to the Maori and non-Maori categories.

## **Mortality rates and life expectancy**

New Zealand has a long time series of life expectancy estimates compiled in a consistent way. The Maori mortality rates used by Statistics New Zealand to calculate life tables are based on Maori resident population estimates that are adjusted for census undercount and on deaths that are unadjusted for under-reporting of Maori deaths. The Statistics New Zealand 2009 publication *New Zealand life tables 2005–2007* contains a detailed description of changes to the concept and death and population measures used in the life tables since 1950–1952. It acknowledges that Maori deaths were significantly under-identified, and so life expectations over-estimated, before new death registration forms were introduced in 1995. It cautions users not to compare post-1995 estimates with pre-1995 estimates.

The New Zealand Census – Mortality Study of the University of Otago gave some indication of the extent of under-reporting of Maori deaths in pre-1995 periods. It reported high ratios of the estimated number of deaths after linkage to the number of deaths registered (termed the census to mortality ratio in the study) indicating considerable under-reporting of Maori deaths in the pre-1995 periods: 1.39 for 1981–84, 1.55 for 1986–89, and 1.48 for 1991–1994.

This ratio fell to 1.07 for the period 1996–1999 (Ajwani et al. 2003b). For 2001–2004, the study showed that the ratio has declined further to near parity (0.98). The study concluded that there was currently little under-identification of Maori deaths (Blakely et al. 2008).

Statistics New Zealand and the New Zealand Census – Mortality Study both acknowledged the role played by the standardisation of death registration and census forms since 1996 in achieving full reporting of Maori deaths. It is also possible that the registration of Maori deaths is helped by the existence of unique identification numbers that the National Health Index system allocates to each health service users. This unique health care number system makes it possible to check on the ethnic status of the deceased on the National Health Index.

## **Canadian estimates**

A variety of Canadian Aboriginal life expectancy estimates are quoted in the international literature. Among those often quoted are those published by the Indian and Northern Affairs

Canada (INAC) in their annual publication entitled *Basic departmental data*. In this publication, life expectancy of Registered Indians (not the entire Canadian Aboriginal population) is presented. In the 2004 edition of this publication, the life expectancy data was sourced from another INAC publication called *Population projections of Registered Indians 2000–2021* published in 2003 (INAC 2003). The Canadian Indian Register contains considerable demographic details of Status or Registered Indians, including deaths. The life tables produced by INAC are of Registered Indians, and are calculated by relating deaths reported to the Indian Register (adjusted for late and never reported deaths) to the number of people in the Indian Register, which is also adjusted for late and never reported deaths and births (Verma et al. 1999; Verma & Gauvin 2004). These adjustments included the addition of late vital events reported to the registry after the reference period, and the use of regression to estimate those vital events that were not yet reported. In addition, indirect demographic estimates of deaths of those aged less than 1 year and more than 74 years were made using the Brass model (Brass 1968). INAC Registered Indian life expectancy estimates are quoted by Health Canada and reported in Health Canada's routine report *Healthy Canadians – a federal report on comparable health indicators*.

Data linkage methods have been used by Statistics Canada to estimate mortality of Canadian Aboriginal people. The Canadian Census Mortality Follow-up Study linked a 15% sample of 1991 Population census records to death records to track the mortality of this cohort until the end of year 2001. Aboriginal status data from the Census were used to identify the different indigenous groups. In this linkage work, encrypted names from a nominal list that was abstracted from taxation records were transcribed onto the Census records for matching with the named death records. Because taxation records do not include children and many young people, linkage was only done for people aged 25 and over, thus restricting any mortality and life expectancy estimates from this study to these adult ages (Wilkins, Tjepkema et al. 2008). Estimates of life expectancy of Canadian Métis and Registered Indians aged 25 years and over based on this linkage work were published in 2009 (Tjepkema et al. 2009).

In other data linkage studies, death records from the death registration system were linked to Canada's Indian Register's Status Verification System (SVS) to complement the death database. In a study of First Nations in Manitoba, it was shown that the Manitoba Population Health Research Data Repository (containing health services usage data, as well as vital registration data) under-identified First Nations by 20% (Jebamani et al. 2005). A further study used a similar linkage method to improve the identification of First Nations for the analysis of infant mortality among First Nations and non-First Nations in British Columbia (Luo et al. 2004).

Statistics Canada has published premature mortality estimates in areas with high concentration of Aboriginal populations (Allard et al. 2004). It has also published total population life expectancy estimates for areas in which there were high concentrations of Inuit people (Wilkins, Upall et al. 2008). Analysis was also made of birth outcomes in these areas (Luo et al. 2010). In these studies, areas with a certain percentage of indigenous population were chosen. The conceptual and method issues of such ecological studies were discussed in a Statistics Canada publication (Fines 2008).

## **Population census data for Canadian Aboriginal people**

Recent Canadian censuses used a short form and a long form to collect information about the population. The short census form was administered to 100% of the population, and did not

include questions on the Aboriginal status of the population. The long form contains three questions to ascertain the various Aboriginal groups in the population.

- Is this person an Aboriginal person, that is, North American Indian, Métis, or Inuit (Eskimo)?
- Is this person a member of an Indian Band/First Nation? If yes, specify Indian Band/First Nation.
- Is this person a Treaty Indian or a Registered Indian as defined by the Indian Act of Canada?

In the 2006 Census, the long form was administered to a sample of 20% of the population.

Answers to the three questions were used to estimate the number of First Nations, Registered Indians and other Aboriginal groups. The term First Nations refers to those who identify themselves as North American Indians. Registered Indians refer to those who claim to be a Treaty or Registered Indian. The overall Aboriginal population (also called Aboriginal identity population) are: those who reported identifying with at least one Aboriginal group – that is, North American Indian, Métis or Inuit; and/or those who reported being a Treaty Indian or a Registered Indian; and/or those who reported they were members of an Indian band or First Nation.

## **Death data for Canadian Aboriginal populations**

Death data are compiled and published by Statistics Canada from information provided by provincial and territory registrars of births, deaths, and marriages. Information on the Aboriginal status of the deceased is not collected in the death registration form, so is not available to Statistics Canada to compile death data classified by Aboriginal status.

Aboriginal status information is, however, available from the 20% of the population who complete the long form of the Canadian five-yearly population Census, and from the Indian Register's Status Verification System. By linking death registration records to the Census or Status Verification System records, a subset of Aboriginal deaths can be ascertained.

## **Mortality rates and life expectancy of Aboriginal Canadians**

Mortality rates and life expectancy estimates are not available for the Canadian Aboriginal population as a whole, despite the various methods used to overcome current data deficiencies.

The estimates published by the INAC are restricted to Registered Indians, and are based on the Indian Registration System, with adjustments to overcome the deficiencies in the system. The life expectancy estimates do not apply to Indians who are not registered. The 2006 Canadian population Census estimated 1.17 million Aboriginal people in Canada, of whom 60% were North American Indians. Of self-reported North American Indians, 81% were Registered Indians (Statistics Canada 2009). The coverage of the Canadian Indian Register is affected not only by the propensity of individual Aboriginal people to register but also by regulation changes that affect the eligibility to register. The 1985 amendments to the *Indian Act* (Bill C-31) restored Indian status and membership rights to people who were not eligible before, such as Indian women who married non-Indians. These amendments resulted in a jump in the number of Indians registered in 1985 and subsequent years until the mid 1990s (INAC 2005).

The Census Mortality Follow-up Study generated estimates for those aged 25 years and over, but not for all ages. More importantly, the use of taxation records to help data linkage has meant that the results would be biased towards those Aboriginal people who have filed tax returns. This population can be expected to be different, probably of higher socioeconomic status, from those who have not filed tax returns. As a result, life expectancy estimates from the Census Mortality Follow-up Study cannot be taken as representative of life expectancy of the overall Aboriginal population.

Similarly, mortality and life expectancy estimates from linkage to the Canadian Indian Status Verification System are restricted to those who are registered. It can be expected that the socioeconomic profile of those who are registered with the Status Verification System is different from those who are not, thereby resulting in biased estimates of mortality and life expectancy. Also, the proportion of Indians who are registered may differ from area to area and between different Aboriginal group, making it difficult to make comparisons between areas and groups. Life expectancy estimates from linkages to the Status Verification System cannot be expected to accurately represent the situation for all Aboriginal Canadians. The linked database would need to be further improved by using additional sources of data that also have good Aboriginal identifying information.

Ecological studies that focus on areas with high concentration of Aboriginal populations cannot be expected to result in accurate estimates of life expectancy for the groups that are not highly represented in the areas. This is because the mortality of Aboriginal people in non-Aboriginal concentrated areas cannot be expected to be similar to that of non-Aboriginal people in Aboriginal concentrated areas. Further, analysis of changes in life expectancy over time using ecological studies is also problematic because the degree of concentration and dispersion may change over time. Ecological studies are not an unbiased or a reliable substitute for direct estimates of life expectancy of the Aboriginal population unless they take these factors into account.

## **United States of America estimates**

Official national estimates of mortality and life expectancy are published by the USA National Center for Health Statistics (NCHS), but the USA Indian life expectancy estimates most often quoted in the comparative literature are those produced by the USA Indian Health Services (IHS). These estimates are published each year in a publication entitled *Regional differences in Indian health*. They are used in other IHS publications and by other USA and international agencies.

These estimates relate to American Indians and Alaska Natives (AI/ ANs) who live in IHS serviced areas 'on or near reservations'; they do not relate to all AI/ ANs in the United States. In 2000, according to the 2002 Census, only about 57% of all AI/ ANs lived in IHS serviced areas (IHS not dated).

## **Census population data for American Indians and Native Alaskans**

The USA population censuses, done every 10 years, have always included a question on the race of each person, as well as a separate question on Spanish, Hispanic or Latino origins. The race question in the 2000 Census was 'What is the person's race?' and it included 13 response categories and a residual category of 'some other race'. Respondents were asked to tick one or more boxes, so that persons of mixed races could be identified. AI/ AN was one

of the answer boxes that could be chosen. Those who ticked AI/AN were then asked to write down the name of the tribe that they belonged to.

The USA Office of Management and Budget published a set of guidelines in 1997 that requires race data to be collected and reported for a minimum of five categories – white, black (African-American), American Indian and Alaskan Native, Asian and Hawaiian, and other Pacific Islander. The Hispanic category is in addition to these five race categories. As a result, there are overlaps between the race categories and the Hispanic category so that those who identify themselves as Hispanic can also identify themselves in any of the five race categories. The USA Census Bureau developed a method to assign the ‘some other races’ responses (and presumably non-responses) to one of the five race categories mandated by the Office of Management and Budget.

Censuses before 2000 asked respondents to name a single race with which the respondent most closely identified (IHS not dated). So data on mixed races were not available from censuses done before 2000.

The USA Census Bureau and the NCHS developed a method to convert multiple race responses in the 2000 Census to single race categories – known as ‘bridging’. This conversion is required primarily to enable birth and death rates to be calculated from vital registration data, because not all USA states have converted their racial classification to the new Office of Management and Budget race categories (discussed below). Bridging is also required when data from the 2000 Census are compared with data from previous censuses.

Since the 1990 Census, official USA population estimates have not incorporated any adjustment for census undercount (United States Department of Commerce 2004). But the AI/AN undercount for the most recent Census was estimated to be very small (less than 2%) and not statistically significant (Notzon NCHS pers. comm.).

## **Death data for American Indians and Alaskan Natives**

National death statistics are compiled and published by the NCHS. NCHS obtains death information from state and territory health authorities, which are sourced from official death certificates. AI/AN identification is available on death certificates, and this was based on single race categories until 2003 when a revision of the USA Standard Certificate of Death allowed the reporting of more than one race. Unlike the 2000 Census, multiple race information is not available from death certificates before 2003. Not all USA states have adopted the 2003 revision of the standard death certificate. As of 2007 (the most recent mortality statistics currently available) only 27 of the 52 registration areas (50 USA states plus New York City and the District of Columbia) were collecting multiple race information. Until all registration areas conform to the 2003 Office of Management and Budget race reporting guidelines, the census population data will have to be bridged back to the previous race categories to produce national birth and death statistics by race.

It is known that misreporting of race in death certificates occurs, and that the extent of under-reporting of AI/AN category is much higher than under-reporting of the ‘white’ and ‘black’ categories (Arias et al. 2008). The problem of misreporting of race is acknowledged in routine NCHS vital statistics reports (NCHS 2009).

## Mortality rates and life expectancy

Each year NCHS publishes a series of life tables for the USA: separately for the 'white' population, the 'black' population, and for 'all races'. AI/AN life tables are not published. AI/AN life expectancy figures quoted in the international literature are produced by IHS.

All mortality rates and life expectancy estimates published by the IHS are adjusted for miscoding of Indian race on state death certificates. A study of the extent of miscoding of Indian race was published in November 1996 in a report titled *Adjusting for mis-coding of Indian Race on State death certificates* (IHS 1996). This linkage study matched records of patients of IHS services in IHS areas to death certificates. Death certificates data were provided by the NCHS from the National Death Index. The matching was based on personal details such as names, age, sex, social security number, and marital status. Records for the 3 years 1986, 1987 and 1988 were used. The methods of matching followed those developed by the USA Bureau of the Census, and an independent check of the work was done by the Bureau of the Census.

Results of this study showed that about 11% of National Death Index death records were not correctly coded to AI/AN. This ratio varied greatly between IHS areas – from 30% for the California area and 28% for the Oklahoma area to 2% for the Aberdeen and Tucson areas.

These ratios were used to adjust all deaths data to be presented in IHS publications including life expectancy estimates. The ratios (calculated for the period 1986–1988) were first used in the 1997 edition of *Regional differences in Indian health* to adjust 1997 death data. The same adjustment ratios were used after 1997. The most recent edition for 2002–2003 indicates that the same set of adjustment ratios were used (IHS not dated).

Results of this IHS study do not relate to the entire Indian population in the USA, because the source data used were records of patients and deaths of IHS areas. This restricts the applicability of the study. More importantly, the use of IHS service records to improve death data and to calculate adjustments ratios means that miscoding of death records of those who did not use IHS services would not be reflected. If AI/ANs who don't use IHS services, either within or outside IHS areas, had higher mortality than those who use IHS services, then the degree of under-identification of AI/AN deaths would be under-estimated in the study. The IHS acknowledged that the study did not represent all AI/AN in the USA.

The NCHS has also researched the miscoding of race in death certificates. The most recent NCHS study, published in 2008, was done using data for 1973 and 1978–1998. This study linked death registration records to records of a large national survey that contains race information – the Current Population Survey. The research related to all AI/AN population in the USA, unlike the IHS study, which related only to IHS service users in IHS areas.

Results of this NCHS study showed that the adjustment ratios to account for under-coding of AI/AN deaths records (the 'classification ratios') were 1.45 for 1979–1980 and 1.30 for 1990–1998. These are much higher than the 11% miscoding rates indicated in the more restricted IHS study.

The report also summarised the results of some similar earlier studies done by NCHS. A 1960 study linked death registration with census records. Using the Census as the standard, this study showed 79% of self-identified American Indians were correctly identified on the death certificate. A 1979–85 study that linked death registration to Current Population Survey data found that this ratio (correct identification) was 74%, while an extension of this

study covering 1979-1989 found only 57% agreement. These results showed that there has been a history of considerable under-coding of AI/AN deaths in the USA.

The report also presented age-specific and age-standardised mortality rates for 1999-2000 adjusted for undercount. The adjusted age-standardised rate was 31% higher than the unadjusted rate. More importantly the report notes:

The overall mortality for the AI/AN population is probably even higher than the adjustment suggests. The extremely low death rates (even after correction) for the older age groups, where the corrected ratio to the white death rate drops from 1.51 in the age group 65-74 years to 0.99 in the age group 75-84 years and further to 0.76 in the age groups 85 and over is unrealistic (p9).

The reliability of AI/AN female deaths is particularly questionable, as the female correction factor varies from 0.87 (that is, over-reporting of female deaths) for those aged 25-44 years, to 1.55 for those aged 45-54 years, back to 0.96 for those aged 55-64 years, and a return to 1.92 for those aged 65-74 years. Such variability raises serious doubts about the adequacy of the AI/AN linkage data for use in measuring AI/AN life expectancy. The report did not contain life expectancy estimates.

An adjustment ratio of more than 30% for AI/AN was quoted in a more recent NCHS report (2009). But it appears that these adjustment ratios have never been used, either by NCHS or the IHS. The 2009 NCHS report alerts readers to the considerable undercount of deaths for the AI/AN group, but no adjustment is made to death numbers, and death rates of each racial group are calculated without under-reporting adjustments. Life table series compiled by NCHS are restricted to the categories 'white' and 'black'. The IHS produces AI/AN life expectancy figures, but again these have not used results of these NCHS evaluation studies.

# Published comparisons of indigenous life expectancies

This section reviews papers and articles in the international public health research and broader health information and policy literature, which have presented comparisons of the life expectancy of indigenous people (or the life expectancy gap) for two or more of the four countries of interest. Unless otherwise indicated, 'life expectancy' will refer to life expectancy at birth. The gap is the difference in life expectancy between a country's indigenous and non-indigenous populations, but is sometimes approximated by the difference between the country's indigenous population and either the total population, or the dominant anglo-European or 'white' population.

The primary aim of this section is to determine the dominant messages that these comparison papers have presented; that is, what conclusions a reader of these papers would most likely take away. More specifically, questions considered include the following:

- What are the relative magnitudes of life expectancy estimates and/or magnitudes of gap estimates in the different countries presented in the papers?
- Do the papers draw conclusions, either quantitative or qualitative, about the relative magnitudes of indigenous life expectancy (or gaps) in the different countries, and how confidently or otherwise are these conclusions expressed?
- Are specific reasons given for the strength or lack of confidence in conclusions?

Secondary questions that will be considered in this section include the following:

- What are the source documents and methods for the life expectancy and gap estimates cited in the comparison papers?
- How have the authors of the comparison papers handled uncertainty or limitations about the estimates they use?

## Papers presenting country comparisons

A search of the literature has revealed 16 papers published since 1990 featuring comparisons of indigenous life expectancy estimates (or estimates of life expectancy gap) between two or more of the four countries of interest. The 16 papers are collectively referred to here as country comparison papers to distinguish them from other papers in the literature that deal with indigenous life expectancy estimates for a single country. Some of their key features are summarised in Appendix tables A1 and A2. One paper included (Ring & Firman 1998) only presents standardised mortality rates and not life expectancy estimates. All but one of the remaining papers present life expectancy estimates from birth only. The exception, Hogg (1992), presents estimates of life expectancy from both birth and from 20 years of age.

Only a small number of the papers have comparative quantitative analysis of indigenous life expectancy across countries as a major focus (Trovato 2001; Kunitz 1990; Bramley et al. 2004 and 2005) (or mortality analysis in the case of Ring & Firman 1998 and Hogg 1992). Even for these papers, the primary point of interest of their authors often appears to lie less with establishing with statistical rigour which countries have the greater gaps or lower indigenous life expectancies, and more with exploring possible differences between and within countries in social/cultural/historical disadvantage. They then thereby offer

explanations for the gaps between indigenous and non-indigenous life expectancies (Trovato 2001; Kunitz 1990), or discuss the policy changes that might be needed to tackle poor life expectancy (Ring & Firman 1998; Ring & Brown 2003).

Some of the cited papers present tables summarising estimates of indigenous life expectancy (and/or gap) across countries as part of introductory descriptive statistical accounts before presenting often quite extensive and broad-based consideration of indigenous health, health services, and related issues in the four countries (Anderson et al. 2006; Freemantle et al. 2007; AIHW 2009).

A few are simply broad compendia of descriptive statistical information, presented as unquestioned facts, relating to indigenous people from the four countries covering a wide variety of issues within indigenous affairs often well beyond health. Typically, the reference to indigenous life expectancies in these publications is cursory, and country differences are often provided without any comment or discussion (Dow & Gardiner-Garden 1998; Martins 2002; UN 2009; Hanemann 2006). In addition, some papers (UN 2009, for example) refer to outdated data. These documents have been included in this review as they are possibly no less influential than other reviewed publications in informing and reinforcing public opinion and professional and government perceptions about country differences in indigenous life expectancy. No doubt other similar publications exist to the ones listed here.

One paper (Cooke et al. 2007) uses indigenous life expectancy comparisons along with summary statistics for income and education attainment to calculate the United Nations human development index (UNDP 2003) for indigenous people in the four countries of interest. The available data, after some interpolation, are used to generate life expectancy estimates allowing country comparisons for 1990–91, 1995–96 and 1999–2000. Few other papers present any time trend estimates for different countries, two exceptions being Kunitz (1990) and Trovato (2001).

Yet another paper (Hill et al. 2007) presents summary comparisons of the gap in indigenous life expectancy for the four countries after using a new indirect estimation method (new to indigenous life expectancy estimation) to derive estimates for the life expectancy for Australian Indigenous people.

## Sources of life expectancy estimates

The sources of estimates of indigenous life expectancy presented in the country comparison papers have all been referenced with the exception of Cooke and others (2007) who state that they are “...the best that are available from official sources...”. Referenced sources have usually been national government statistical or health agency reports from one of the four countries (see Appendix tables A1 and A2), or a publication that has itself sourced estimates from a government source. Sources of estimates for some papers published in the early 1990s, which was before some government agencies routinely published estimates, were either academic literature or sometimes unpublished government sources.

Some early Indigenous Australian estimates are derived for the Indigenous populations of geographically remote regions of the country, where data was thought to be more reliable or because data were not available elsewhere. One author, Kunitz (1990), cites four different Indigenous life expectancy estimates for Australia, all from different but predominantly remote and rural regions. Noting the similarity in the magnitude of the estimates and the geographically dispersed regions from which they were derived, Kunitz concluded that this was grounds for assuming similar life expectancy across the whole country. However, the

absence of the more urban section of the Indigenous population may have resulted in a biased picture of Australian Indigenous life expectancy. This is an example of an important source of potential biases that can result from using estimates derived for a distinct subgroup of a country's indigenous population to represent national life expectancy. It is possible that many of the ABS Indigenous Australian estimates used in country comparison studies may be subject to a form of this bias because of their heavy direct or indirect reliance on presumed better recorded death data from the western third of Australia's Indigenous population (such as Western Australia, Northern Territory and South Australia).

This bias is also a possible problem with many of the Canadian indigenous life expectancy estimates used in comparison studies reviewed here. Some comparisons make use of estimates relating to Registered or Status First Nations, which according to the Canadian Census results exclude more than a third of indigenous Canadians (see above). Canada is unique among the four countries in not having an indigenous identifier on death certificates, so most estimates produced by Statistics Canada rely on approaches that match census or register records of First Nations to death records. Biases can result if life expectancy estimates for this group are interpreted as estimates for the country's whole indigenous population. While many of the comparison papers acknowledge that Canadian indigenous life expectancy estimates are for a subpopulation, few accept that national comparisons involving Canada are unreliable.

Nearly all the USA indigenous life expectancy estimates quoted in comparison studies are taken, directly or indirectly, from IHS publications, and appear to have more significant issues than those for Canada. Not only do IHS life expectancy estimates potentially suffer from a subgroup bias, but they are also open to substantial bias resulting from the use of an adjustment factor to correct for under-reporting of indigenous status on death certificates. Most estimates have used the same adjustment factor derived from a study done with data relating to the 1980s. However, more recent studies suggest under-reporting may have been much larger than previously estimated.

Most indigenous life expectancy estimates for New Zealand used in comparison studies, and in all recent ones, have been derived as part of the New Zealand Census - Mortality Study lead by Tony Blakely (for example, Ajwani et al. 2003a & 2003b, and Blakely et al. 2005). Although other estimates are produced by the official New Zealand government statistics agency (for example, Statistics New Zealand 2009), those from Blakely's group are widely thought to be the most reliable estimates available, and the method is viewed as something of a gold standard for all four countries (Hill et al. 2007). But even this method is not without problems.

## **Handling uncertainty in indigenous life expectancy estimates**

None of the published country comparison papers present quantitative statistical analysis in support of conclusions about differences between countries. In fact, with the exception of Hill and others (2007) who did some sensitivity analysis of their new Australian life expectancy estimates, no papers present either standard errors or sensitivity analyses of any cited estimates.

This lack of quantitative consideration around the uncertainty of estimates is understandable, given that standard errors are rarely presented with estimates of indigenous life expectancy when they are derived, even where they have been calculated.

In the absence of quantitative analysis in support of conclusions, some papers present quite accurate, and more or less comprehensive qualitative descriptions of the varied and complex factors that can introduce uncertainty or bias into the magnitude of individual country estimates of indigenous life expectancy, and, even more, into comparisons between countries. It is noteworthy that papers published in the earlier part of the study period (1990–2009), notably Hogg (1992), provide some of the more comprehensive accounts of these issues.

Of all the papers, Bramley and others (2004) probably provides the most comprehensive account of factors that bring uncertainty to comparisons of indigenous life expectancies between countries. These issues included differences in approaches to the definition and measurement of ‘indigenous’ used in various countries, and, in some instances, between data collections within a country. Bramley also discusses the availability of national data sets, which may not be available or reliable because of data quality limitations. Methodological differences also exist more often than not between countries in the approaches used to estimate indigenous life expectancy.

Despite the thorough accounts of the potential sources of uncertainty presented in some papers, a large minority of the reviewed comparison papers present country estimates with no suggestion that uncertainties exist about their magnitude or comment on the need for caution when making comparisons (Dow & Gardiner-Garden 1998; Trovato 2001; Martins 2002; Ring & Brown 2003; Hanemann 2006; Anderson et al. 2006; Cooke et al. 2007; UN 2009).

## **Conclusions drawn in comparison papers about country differences**

With the necessary data collection and method to support the estimation of indigenous life expectancy probably not sufficiently developed and coordinated across countries to support formal inferential statistical analysis of country differences, it is not surprising that many papers have avoided discussing differences at all, let alone drawing any conclusions about country differences (Trovato 2001; Hanemann 2006; Anderson et al. 2006; Cooke et al. 2007; UN 2009). Some authors have clearly stated their considered view that making inferences regarding country differences cannot be reliably done (Freemantle et al. 2007; AIHW 2009) and have consciously resisted the temptation to do so, even in the face of what might appear compelling apparent evidence.

After careful consideration of available estimates and issues affecting the uncertainty surrounding country comparisons, Bramley and others (2004) said that “although it is impossible to quantify the exact amount of measurement bias that may exist in our calculations, the data presented here is the most reliable currently available”. This frank but somewhat frustrating summary is perhaps an accurate account of the situation faced by all authors of comparison papers wishing to make valid comparisons and to draw robust conclusions about indigenous life expectancy differences between countries.

The authors of several comparison papers made some observations about the relatively low life expectancy estimate (or larger gaps) for Australian Indigenous people compared with other country estimates (Kunitz 1990; Hogg 1992; Dow & Gardiner-Garden 1998; Martins 2002; Ring & Firman 1998; Ring & Brown 2003; Bramley et al. 2004; Hill et al. 2007).

Only a few papers venture beyond pointing out the apparent ‘outlier’ nature of Australian Indigenous life expectancy, and draw conclusions about differences between other countries.

- Kunitz (1990) states that USA Indians have the highest life expectancy.
- Bramley and others (2004) state that Australia and New Zealand have the greatest gaps.
- Bramley and others (2005), who compared USA and New Zealand data only, conclude that New Zealand has the larger gap.

Sometimes these observations are qualified by cautionary statements about data quality limitation (Kunitz 1990; Hogg 1992; Ring & Firman 1998; Hill et al. 2007). But at other times, qualifications are absent and an unfamiliar reader would gain the impression that a clear conclusion is being drawn (Dow & Gardiner-Garden 1998; Martins 2002; Ring & Brown 2003).

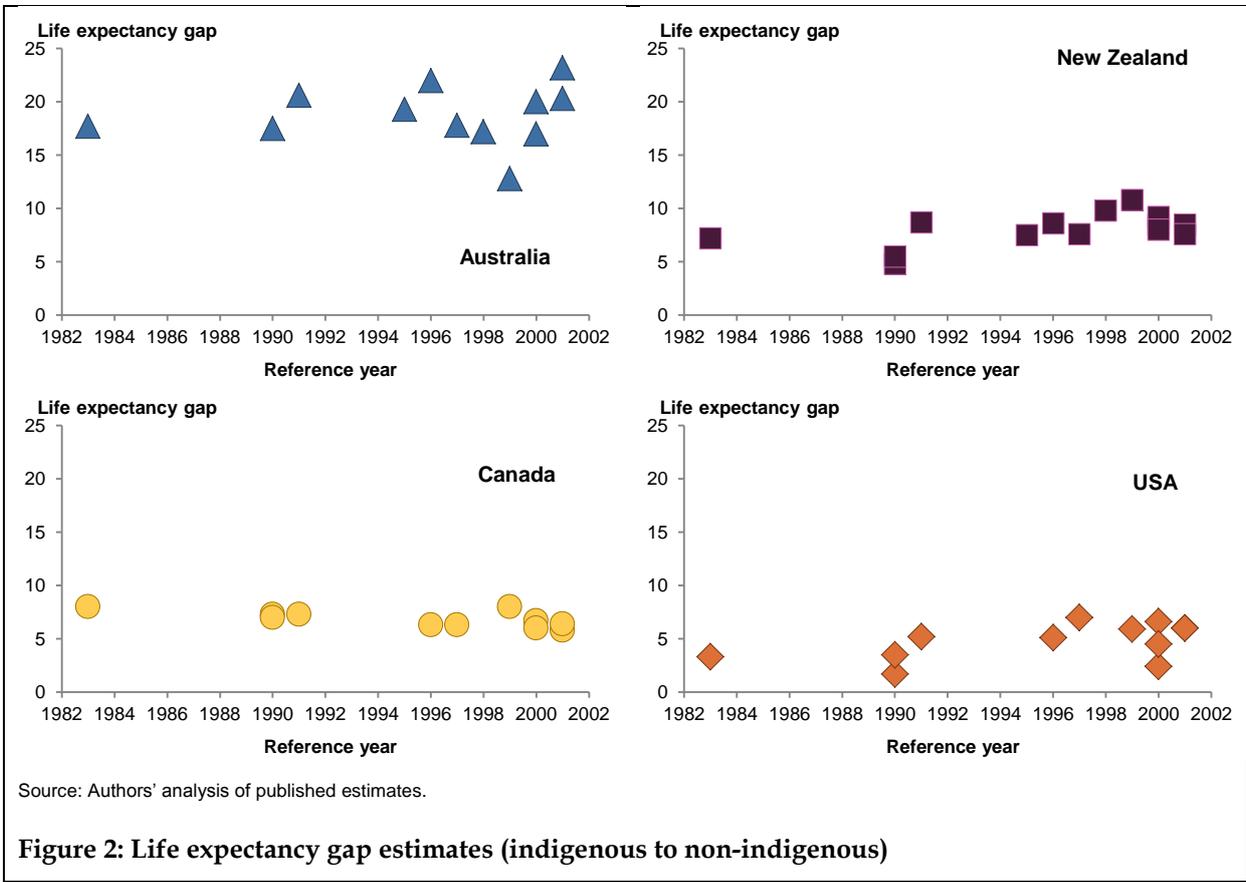
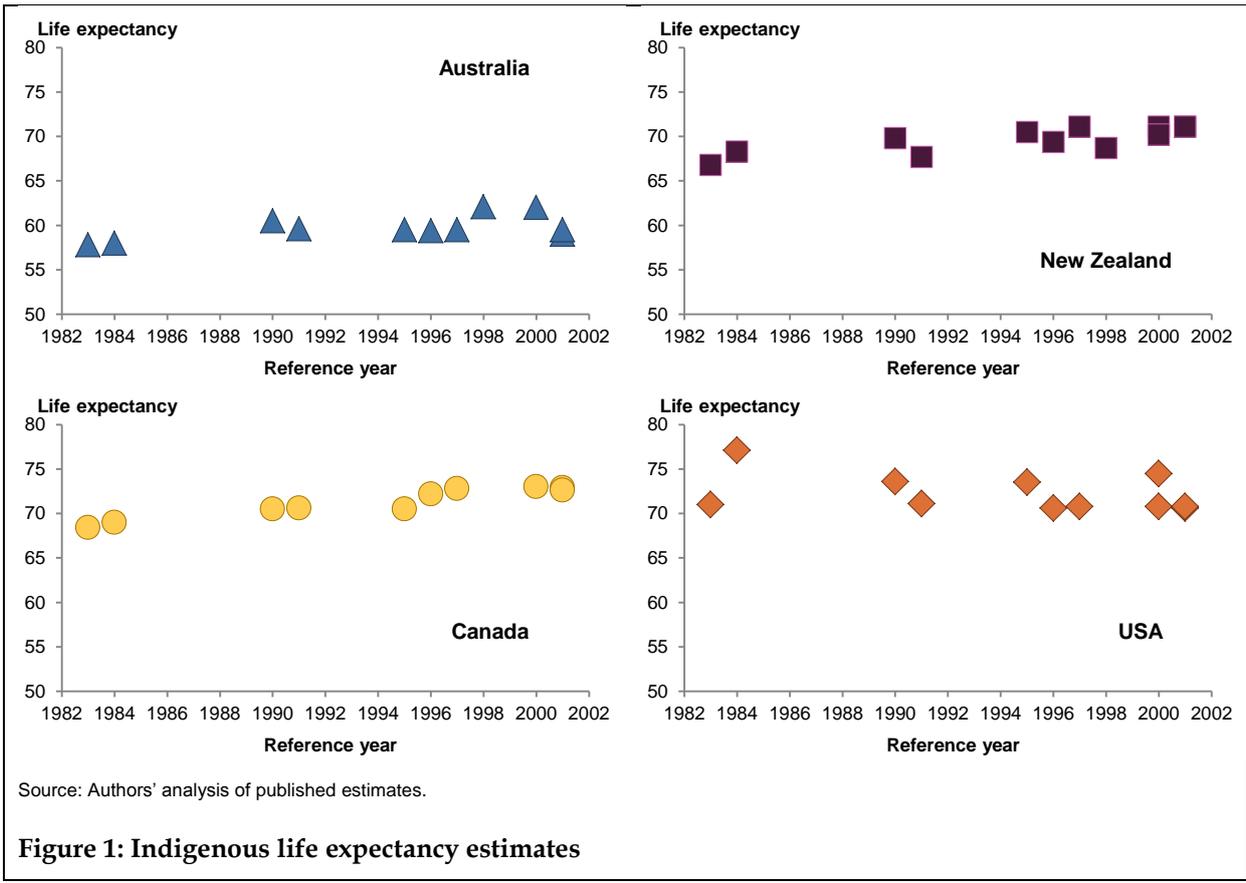
Many authors acknowledged the existence of scope limitations on Canadian and occasionally Australian and USA indigenous life expectancy estimates when drawing conclusions about differences between country estimates. But as most authors have not been primarily interested in comparing national indigenous life expectancies, they have only generally felt obliged to note these scope restrictions, rather than seeing them as severely curtailing the inferences being drawn.

When the presentation of estimates is such that a conclusion that countries differ might be expected to be inferred by a reader, it is often not clear whether authors had conveyed this message unintentionally through a desire for brevity, or whether, on the contrary, the authors themselves believed it to be true and have not encountered or not understood warnings from their source documents about the need for caution and qualifications when interpreting these estimates or comparing them with others.

## **What message do the comparison papers collectively convey?**

Irrespective of whether individual estimates of indigenous life expectancy are accurate or not, and despite any qualifying and cautionary information provided, presenting comparisons of country estimates conveys a message about the relative magnitudes of indigenous life expectancy. The aggregate message conveyed to readers of all 16 of the reviewed papers is summarised in the figures below. Estimates of indigenous life expectancy (Figure 1) and the life expectancy gap (Figure 2) are plotted against the average ‘reference’ year to which the country estimates pertain.

Both indigenous life expectancy and the life expectancy gap are shown as some papers only provide one measure. Where separate male and female life expectancy estimates have been presented in papers, these have been averaged to estimate total life expectancy. The average ‘reference’ year for a publication has been crudely estimated as the average of the midpoints of the time period to which each life expectancy estimate refers.



The two sets of figures convey similar though not identical messages. The dominant message apparent is that Australian Indigenous life expectancy estimates are consistently much lower than those for other countries (or gaps are much larger). The New Zealand life expectancy estimates are also generally lower (gaps larger) on average than those for Canada and United States. Canadian indigenous life expectancy estimates tend to be slightly lower (gaps higher) on average than those for USA. These messages, if taken at face value, are quite clear. We suggest messages of this type, delivered and consolidated from the various comparisons published over the years, have contributed substantially to the widely held view that Australian Indigenous life expectancy is much lower than that for New Zealand Maori, which in turn is lower than for indigenous North Americans. We have pointed out that in Australia, there is a worrying negative correlation between the availability of death data for particular groups and their estimated expectation of life. We suggested that this may reflect the fact that data is more easily collected from those people living in defined Indigenous communities (often in remote geographical regions) where health status is often considered to be poorer than in other parts of Australia. We note another correlation in the international data: countries that have adopted the least inclusive definitions of 'indigenous' in their health and population data collection systems, report the best life expectancy estimates. This may well reflect less adequate ascertainment of indigenous deaths among those with more distant relationships with the state.

A second observation to be made from the graphs is that there is relative consistency in life expectancy (or gap) estimates for a given country, with the most recent Australian estimates being a notable exception (see later discussion). This consistency reinforces the dominant messages. However, this consistency is misleading, and is caused, in part, by a considerable degree of dependence between individual country estimates. This includes the occasional citing of an identical estimate for a country in two different comparison papers. However, a much more important source of misleading and spurious consistency is that the methods (and data) used to generate the indigenous life expectancy estimates used for different years (and in different comparison papers) for a given country may be the same, or very similar; so estimates may consistently suffer identical, or almost identical biases. For these reasons, the dominant message from figures 1 and 2, along with the commonly held opinion of people working in this field, should not go unquestioned or untested.

## **What should be concluded about country differences?**

The lack of independence of many of the comparisons made in the 16 reviewed papers, and the uncertainties and possible biases attached to individual or even groups of estimates, raises the question of whether the compelling message of figures 1 and 2 should be believed, or whether the figures are misleading, at least in their apparent strength, if not altogether.

To provide a definitive answer to this question it would be necessary to have quantitative information on the overall magnitude of error (from all sources of bias as well as any caused by finite sampling) to which each estimate is subject. At present this cannot be done, so it cannot be inferred in a classical statistical sense that there are differences between countries in indigenous life expectancy, let alone the relative magnitude of differences. Of course, this conclusion does not preclude that real, even large differences might exist, only that it should not be inferred from the available information.

However, it is reasonable to raise the hypothetical question of what conclusions might probably be expected if accurate information were available on the magnitude of errors and possible biases in these estimates. To address this question, insight into the possible magnitude of overall errors is necessary. Some insight can perhaps be gained, at least informally, by looking at (and cautiously speculating about) the potential for different types of bias and uncertainty for each country. And, from this, considering what might be the possible magnitude of the overall certainty attached to estimates, we might speculate on the outcome of imagined hypothesis tests for differences between estimates.

To demonstrate, this has been attempted in tables 1 and 2 for most of the methods that have been used to derive estimates in recent years for the different countries. It is recognised that tables 1 and 2 include some unavoidable subjectivity. Table 1 notes the likely importance of different sources of error to each of several methods when used with the data for a particular country. The various source of error either affect the estimates of population or numbers of deaths used in the mortality and life expectancy calculations. The specific sources considered are listed below. This list is not comprehensive and probably not fully mutually exclusive. Given that the reason for presenting this table is for illustration rather than to give the impression of being comprehensive or completely precise, the limitations are considered acceptable. The sources of error considered in tables 1 and 2 are:

- errors due to indigenous population records not conforming to indigenous definition
- bias caused by regional or subgroup estimates not being representative of the national indigenous life expectancy
- errors in population estimate, such as undercount, or non-recording of indigenous status
- mismatch between population and death record systems in their concept of indigenous status – that is, even if operational errors were avoided
- errors caused by incorrect direct adjustment for operational under-recording of indigenous deaths or under-recording of indigenous status on death records
- biases due to matching failures and failure of assumptions about the indigenous status of unmatched records
- errors arising from use of indirect methods – that is, failures of the statistical model and, particularly, extreme sensitivity of estimates to errors in population age distribution (see Barnes et al. 2008).

Each of the methods in recent use in each country, and the data sets with which they are or would be used are considered and allocated an ordinal score indicating the relative importance of each source of potential error (see final column in Table 2). To provide a quantitative base for our speculations, the scores have been assigned a value approximating the magnitude of the combined error they describe. As indicated, the various errors operate on either population estimates or estimates of numbers of deaths. Note that a given percentage error on either the population estimate or the estimate of numbers of deaths will result in an error of about the same relative magnitude on estimates of mortality rates. Supposing the sources of error function roughly independently, a speculative indication of the possible magnitude of the total relative error that could be associated with mortality rate estimates has been constructed by roughly applying a root-mean-square rule – that is, assuming errors are independent and additive when squared.

Each source of error is first considered in more detail in relation to the methods and the country's data sources and systems in Table 1.

**Table 1: Major potential sources of error and bias in mortality estimates for key methods**

Source of possible error	How it might affect different estimates
i) Errors due to indigenous population records not conforming to indigenous definition.	Each country has a formal definition of indigenous status, but even if all operational procedure in place are carried out perfectly, the indigenous status recorded in records may be different to what it should be according to the formal definition. For example, in Australia there is a three-component definition, but operational procedures usually only involve one (self-identification). It is supposed that all countries and methods are affected moderately by this type of error.
ii) Bias caused by regional or subgroup estimates not being representative of the national indigenous life expectancy.	Some Canadian and USA estimates are based on 'Registered Indians'; if estimates are interpreted as being for the whole indigenous population, this type of error will result. It is considered that these errors could be quite large.
iii) Errors in population estimates—for example, undercount, non-recording of indigenous status.	For some methods the population must be estimated from census counts or another source. This error will occur in so far as the estimates differ from the true indigenous population. Some linkage methods use a population defined by a linked file, and are not subject to this error, but are subject to error (v) if the people not on the linked file have different death probabilities. USA estimates are likely to have the greatest potential error of this type, as census counts are not adjusted to derive indigenous population estimates. Australian Indigenous population estimates are possibly subject to fewer errors than other countries, as Census counts are adjusted for visitors, unstated indigenous status, and specific adjustment for non-counting of Indigenous people. New Zealand does not apply the last of these corrections.
iv) Errors caused by incorrect direct adjustment for operational under-recording of indigenous deaths or under-recording of indigenous status on death records.	This error is caused by operational failure of death record data capture procedure, and the failure to adjust correctly for this (either no adjustment made or the adjustment is not estimated correctly). Again, methods that use record linkage to impose the indigenous status of the population file onto the death records will not suffer this source of error. It is considered that the USA IHS estimates may have very large errors of this type, because adjustments used may be severely in error. National indigenous Canadian estimates will not have this error. Statistics New Zealand estimates may suffer moderately from this error because Maori status is not adjusted on death records. The AIHW Australian method may suffer from this error moderately, as, although it is a linkage method, it does not impose the population file's indigenous status on the death records. The method also has the potential to over-adjust for non-recording of indigenous status on death records. The direct ABS post-enumeration survey (PES)-based adjustment method should, in theory, avoid this error completely, except for the sampling error uncertainty introduced through the post-enumeration survey. However, current corrected numbers of indigenous deaths for some Australian states are almost certainly incorrect by about 10%.
v) Biases due to matching failures and failure of assumptions about the indigenous status of unmatched records.	This is the big unknown potential source of error for record-linkage studies in this area. The errors in the New Zealand linkage work may be smallest, as a probabilistic linkage method is used and the possibilities of bias of this type have been extensively explored and concluded to not be excessive, although variance may be large. The potential for errors in the Australian ABS post-enumeration survey–Census linkage method may be high, as 30% of death records are unmatched. Less is known about the north American linkage studies but it is possible the errors could be high.
vi) Errors arising from use of indirect methods—that is, failures of the statistical model.	Extreme sensitivity of life expectancy estimates to errors in population age distributions has been show to result from this and other indirect life-table estimation methods (Barnes et al. 2008). It is considered that potential errors in this method are extremely high. The score of 'very large' assigned to the magnitude of potential errors of this type that might result from using the indirect method of Hill et al (2007) indicates the approximate potential magnitude of error on mortality estimates.

**Table 2: Major potential sources of error and bias in mortality estimates for key methods and score of indicative sizes of errors<sup>(a)</sup>**

Country	Estimation method <sup>(b)</sup>	Errors due to population not conforming to indigenous definition	Bias due to subgroup not being representative of nation	Errors in population estimate	Mismatch of pop/death register indigenous classification	Errors due to incorrect direct adjustment for under-recording of deaths	Biases due to matching failures and assumptions about unmatched death records	Errors arising from indirect methods <sup>(c)</sup>	Overall indicative potential error
Australia	Hill et al. (2007)	Moderate	Nil	Nil	Moderate	Nil	Nil	Very large	Very large
Australia	ABS—direct estimation and death adjustment by Census linkage	Moderate	Nil	Small	Nil	Small to moderate PES-based death adjustments	Large	Nil	Large
Australia	AIHW—Enhanced Mortality Database	Moderate	Nil	Small	Moderate	Moderate Enhanced database adjustment	Moderate	Nil	Large
New Zealand	Blakeley—Census—deaths linkage	Moderate	Small to moderate	Nil	Nil	Nil	Small to moderate	Nil	Moderate to large
New Zealand	Statistics New Zealand	Moderate	Nil	Moderate	Small to moderate	Moderate Adjustment not done	Nil	Nil	Large
Canada	Statistics Canada—15% Census sample linked to deaths	Moderate	Large	Nil	Nil	Nil	Large	Nil	Very large
Canada	Statistics Canada SVS linkage	Moderate	Large	Nil	Nil	Nil	Large	Nil	Very large
United States	IHS—link deaths to IHS register	Moderate	Moderate to large	Nil to small	Moderate to large	Very large	Nil	Nil	Huge

(a) Ordinal scale for scores—Nil: not applicable or negligible error; small: up to 5% error; moderate: up to 10% error; large: up to 20% error; very large: up to 30% error; huge: could be more than 30% error.

(b) See Appendix table A.3 for more information about methods.

(c) Includes model failure and sensitivity to errors in population distribution.

The scores (and their approximate quantitative conversions) in the final column of Table 2 are an indication of the uncertainty that might exist in mortality estimates derived while calculating life expectancy estimates. Previous simulation studies (Barnes et al. 2008) demonstrated that overall errors of 5–10% in population or death estimates can, on their own, produce changes in life expectancy estimates of about 1–2 years, and that changes of 20–40% (equivalent to a ‘large’ to ‘huge’ score) in population and death estimates might correspond to 4–8 years change in life expectancy estimates. This suggests that, according to the speculations of Table 1, the overall uncertainty (approximate standard errors) attached to each of the various indigenous life expectancy estimates might be of this magnitude. Some would be expected to be towards the lower end of the range and other towards the upper end. If the various sources of error and bias are largely independent from one country’s estimate to another, then approximate standard errors of difference of 5–10 years are plausible.

So even with improved methodological knowledge about current estimation methods enabling formal statistical inference to be made, without improvement in the methods and the data used, it still might not be possible to conclude anything about differences between countries with respect to indigenous life expectancy. This discussion involves a considerable degree of speculation. But even if these speculations are just plausible rather than definitely correct, it is impossible to avoid the conclusion that statistical inferences about country differences in indigenous life expectancy cannot be made with any certainty at present.

## **How should comparisons be made? Or, towards best practice**

Our scrutiny of the various attempts to compare the four countries shows that the comparisons made were sometimes quite simplistic, taking published figures at face value, and assuming that available figures can be used to represent the entire indigenous population of the country. What is the alternative? Is it possible to specify how more up-to-date or more accurate comparisons should be made? The foundation of reliable comparisons is common definitions and methods and improving accuracy needs to be addressed in two ways:

- scope – the inclusiveness or otherwise of the definition of indigenous used
- method – the way in which the statistics of indigenous deaths and populations are obtained.

It could be argued that best practice in terms of scope would involve each country estimating life expectancy for an indigenous population in a way that is as inclusive as that of Australia and New Zealand. The Australian data and methods are far from perfect, but currently, to make Australian (or New Zealand) figures strictly comparable in scope with those published by Canada or the USA, Australian data or estimates would need to be restricted in some way. It is unclear how the defining features of the USA or Canadian subpopulations for which life expectancy estimates are available could be translated to the Australian or New Zealand context; the defining criteria are specific to the constitutional, legal, tribal, social and geographical context of each country. How, for instance, would an Australian group comparable to Status Indians in Canada be specified?

Putting aside measurement errors, published figures that would allow Australia and New Zealand to be compared are already available. In the USA, comparable figures could be

obtained by routinely estimating and adjusting for the undercount of indigenous deaths in the vital statistics system, and using these to estimate life expectancy in conjunction with adjusted population estimates. In Canada, in the absence of national data on indigenous deaths or population, an alternative would be to specifically estimate life expectancy for the various subpopulations, and combine them. The fact that this has not been done to date is presumably because of significant data availability restrictions, which themselves imply institutional resistance to the inclusive approach.

In terms of methods, it seems clear that New Zealand provides the best model, with linkage used to validate and if necessary adjust the estimates derived from death registration and the Census. However, direct nominal linkage within the official statistical system would seem to be more effective than the indirect linkage currently used in New Zealand. The Australian Census linkage project went some way towards this, but it had many shortcomings and failed to link more than 30% of deaths. To the extent that these unlinked deaths reflect lower age at death, and thus higher levels of mortality the life expectancy estimates based on the linkage study will overestimate Indigenous life expectancy. The process of improvement needs to be ongoing, and although nominal linkage to past Australian Censuses is not now possible because the names have been destroyed, statistical linkage could be used as in New Zealand to shed light on trends in life expectancy in the recent past. Linkage of death records to nominal rolls such as the New Zealand Health Index and iwi (Maori social unit) membership, and the use of similar rolls in Australia, would also provide a means of verifying Indigenous deaths, something which is currently done poorly in some Australian states.

The most recent official Australian estimates produced by the ABS incorporate exceedingly complex adjustments to both the reported Indigenous deaths and the enumerated Indigenous population. Further, the specific adjustments are unique to Australia. It is extremely unlikely that any of the other countries discussed in this report would, could, or should replicate these adjustments in detail, so strictly technically comparable estimates of Indigenous life expectancy are unlikely ever to be available. Yet, in principle, this should not invalidate comparisons, if it is accepted that best practice involves adopting the most inclusive definition of the indigenous population, and identifying and adjusting for all known deficiencies in the death and population counts before calculating life expectancy. On this basis, it would seem that comparison of the most recent Australian and New Zealand estimates is probably defensible (even though there are, as yet, no published analyses that do this). But earlier estimates should not be compared with any confidence, and comparisons of any kind with or between Canada and the USA would need to be heavily qualified. So it might be possible to conclude that Maori life expectancy seems to be better than Indigenous Australians' (though the difference may not be statistically significant), but that it is unclear how these two peoples compare with the populations of Aboriginal Canadians or American Indians or Native Alaskans in the USA, or how the latter compare with each other.

# Conclusion

Is it important to know about country differences? Are better international comparisons needed? If so, how might they be done, and would it be worth the effort needed to do the specific studies that would answer these questions? At the level of advocacy, this is clearly an important issue, because so many people have tried to do it, and so much is made of the comparisons they have produced. There have been numerous published attempts to compare life expectancy in the four countries, and those comparisons have attracted considerable attention. If there truly are large differences, it reflects on the level of development and equity in countries, so it is important from a public policy perspective to document and understand the reasons for such differences. If the issue is important, it is essential that the technical basis of the comparisons is sound, but that is far from being the case. It is also important that statisticians – as professionals and as officials – are able to provide estimates in which they and others can have confidence.

Conversely, technical solutions do not stand in isolation from their political and public policy context. The level of inclusiveness of the definition of the indigenous population in each country, the availability of data on population size and deaths for particular subgroups, and the level of commitment to filling the statistical gaps all reflect a country's native administration past and its race relations present. The conclusions and recommendations canvassed in this report can only address the technical issues; their practicability depends on whether there is a will and a capacity to mobilise resources within and between countries.

Despite numerous difficulties, there are many successful examples outside indigenous statistics where internationally comparable statistical series have been developed, or are being developed. Invariably this involves establishing an international working group charged with defining the issues and developing strategies for countries to move towards harmonising their statistical or analytical systems. Sometimes this has been done under the auspices of international bodies such as the United Nations or its subsidiary bodies, the European Union, or the Organisation for Economic Co-operation and Development. Other times it has been sponsored by international professional, technical or civil society organisations. In this case, we believe that this would be an appropriate role for the International Group for Indigenous Health Measurement under an appropriate mandate from its parent committee.

What would such an international group need on its agenda to rigorously establish whether country differences exist? There are two approaches, which are not mutually exclusive. In our discussion we have focused on the action required to enable countries' official statistical systems to be improved by general across-the-board improvements in data availability and quality, and where necessary by estimating correction factors, to allow the reliable estimation of Indigenous life expectancy suitable for international comparison. This would be a gradual process, and it could take a long time to produce more reliable comparisons. A second approach, which could be done in parallel and might produce more rapid results, would be to establish a special purpose international epidemiological study designed to answer the specific question of interest. This could be a prospective survival study, or possibly a retrospective study. Both approaches would require a substantial coordinated international effort, probably under the auspices of an established international body.

# Appendix tables

Table A1: Summary of papers published since 1990 comparing indigenous life expectancy estimates

Source	Reference years	Country and source <sup>(a)</sup>	Life expectancy estimates (years)		Size of gap (years)		Data restrictions and limitations discussed	Discussion of estimation methods	Comment on country differences and conclusion
			Males	Females	Males	Females			
Kunitz (1990)	1980–1985	AU 1, 2, 3	54.0	61.6	17.8	17.5	AU: regional (WA, SA, NT, remote Qld) and national CA: Registered Indian USA: IHS and AI/AN	None	...Aborigines clearly lowest life expectancy ... American Indians have highest life expectancy.
		NZ 4	65.2	68.3	5.6	8.7			
		CA 5	64.0	72.8	8.6	7.3			
		USA 6	67.1	75.1	3.6	3.0			
Hogg (1992)	1981–86 (in the main: 7 different estimates given for Australia)	AU 3, 7, 8,	51.6–55.7	59.9–64.8			Good discussion of data quality issues and restrictions.	No discussion of methods.	Comments on large difference between Australia and other countries.
		9, 10, 11	65.6	70.9					
		NZ 12	64.4	73.6					
		CA13	73.1	81.0					
		USA 14							
Dow & Gardiner-Garden (1998)	Early 1990s assumed (1980s USA)	AU 15	60	61	15–20	15–20	None	None	Australian Indigenous life expectancy lowest.
		NZ 16			5–6	5–6			
		CA 17			7	7			
		USA 18			4	3			
Ring & Firman (1998)	Mortality trends 1980s and earlier to early to mid 1990s	Annual Australian, New Zealand and USA indigenous standardised mortality rates presented for a continuous period (12 to 20 years depending on country) from 1970s to 1990s.		Total Australian trends in standardised mortality presented as a benchmark.		AU: WA and NT data only used NZ: all Maori USA:IHS and AI/AN	Some discussion of data limitations and adjustments done to limits impact on estimates.	Australia pointed out as having higher mortality rates than New Zealand and USA (wrt magnitude of indigenous standardised mortality rates).	
Trovato (2001)	1991 or close to	NZ 19	67.2	72.3	16.6	10.1	No comments on data sources.	None	No comment. No conclusions.
		CA 20	66.9	74.0	7.3	7.1			
		USA 21	69.8	77.4	7.4	7.6			
Martins (2002)	1990s various	AU 22	56	63	20	19	No discussion	None	Australian Indigenous life expectancy lower and gap larger than other countries.
		NZ 23	68	73	8	7			
		CA 24	67	74					
		USA 25	69	78					

(continued)

**Table A1: (continued) Summary of papers published since 1990 comparing indigenous life expectancy estimates**

Source	Reference years	Country and source <sup>(a)</sup>	Life expectancy estimates (years)		Size of gap (years)		Data restrictions and limitations discussed	Discussion of estimation methods	Comment on country differences and conclusion
			Males	Females	Males	Females			
Ring & Brown (2003)	1 or 2 year spans within the period 1998–2001.	AU 26			19–21*		No discussion of any data restrictions	None	Australian gap bigger than other countries. Comments on recent gap decline in all except Australia.
		NZ 27			8*				
		CA 28			5–7*				
		USA 29			4–5*				
Bramley et al. (2004)	2000–2002	AU 30	56.0	63.0	20.6	19.9	Good account of data quality, limitation and definition issues	Good discussion of the methodological issues affecting each country's life expectancy estimation	Australian and New Zealand gaps are concluded to be greatest.
		NZ 31	69.0	73.2	7.3	7.9			
		CA 32	68.9	76.6	7.4	5.4			
		USA 33	67.4	74.1	6.7	5.3			
Bramley et al. (2005)	About 2000	NZ 34	68.0	72.3	8.9	9.4	Some discussion	None	New Zealand gap is stated to be greater than USA gap.
		USA 35	67.4	74.2	7.4	5.8			
Hanemann (2006)		AU 36			20*		Not specified	None	No comment. No conclusions.
		NZ 36			11*				
		CA 36			17*				
Anderson et al. (2006)	1996–2000	AU 37	59.4	64.8	17.2	17.2	No comment provided	None	No comment. No conclusions.
		NZ 38	66.3	71.0	9.3	9.8			
Freemantle et al. (2007)	Probably 1995–2000	AU 44	56	63	16.6	19.0	Little discussion of data sources CA: Registered Indian USA: IHS AI/AN	None	Concludes impossible to make country comparisons because of data and method limitations.
		NZ 31	69.0	73.2	7.3	7.9			
		CA 32	68.9	76.6	7.4	5.2			
		USA 47	67.4	74.2	9.7	5.3			
Cooke et al. (2007)	Three sets 1990–91, 1995–96, 2000–01 interpolation used	AU 39	59.0*		23.2*		No discussion	None	No specific life expectancy comments.
		NZ 39	71.1*		8.5*				
		CA 39	72.9*		5.8*				
		USA 39 (00-01 data)	70.6*		6.0*				
Hill et al. (2007)	Late 1990s to 2000 in case of Australia	AU 40					Detailed discussion of Australia	Detailed discussion of Australian data; short but good discussion for other countries	Australian gap largest but not as large as previously thought. Best statistical consideration of all papers.
		NZ 41							
		CA 42							
		USA 43							

(continued)

**Table A1: (continued) Summary of papers published since 1990 comparing indigenous life expectancy estimates**

Source	Reference years	Country and source <sup>(a)</sup>	Life expectancy estimates (years)		Size of gap (years)		Data restrictions and limitations discussed	Discussion of estimation methods	Comment on country differences and conclusion
			Males	Females	Males	Females			
UN (2009)		AU 49			20*		Not specified	None	No comment. No conclusions.
		NZ 49			11*				
		CA 50			7*				
AIHW (2009)	Mostly 1999–2001 or close to	AU 51	59	65	17	17	Brief but good discussion of limitations in data sources	Australian estimates derived by indirect method; paper points out ABS no longer recommends approach. Key issues of other countries also discussed.	Purposely does not discuss country differences, implies uncertainty about Australian estimates, urges caution on USA estimates.
		NZ 31	69.0	73.2	8.2	8.7			
		CA 53	70.4	75.5	6.7	6.7			
		USA 54		74.5*		2.4*			

(a) See Table A2

\* Figure for males and females combined.

**Table A2: References for source documents of indigenous life expectancy estimates**

Country	No.	Reference
<b>Australia</b>	1	Thomson NJ 1989. Inequalities in Aboriginal health. Unpublished Master of Public Health thesis, University of Sydney.
	2	Khalidi NA 1989. Aboriginal mortality in central Australia, 1975–77 to 1984–86: A comparative analysis of levels and trends. Working Paper. Canberra: National centre for Epidemiology and Population Health, Australian National University.
	3	Gray A & Hogg R 1989. Mortality of Aboriginal Australians in Western New South Wales 1984–1987. Sydney: New South Wales Department of Health.
	7	Gray A 1990. National estimates of Aboriginal mortality 1981–86. In: Gray A (ed.) A matter of life and death. Contemporary Aboriginal mortality. Canberra: Aboriginal Studies Press, p.147.
	8	Plant AJ 1988. Aboriginal mortality in the Northern Territory. Master of Public Health thesis. Sydney: University of Sydney.
	9	Hogg R & Thomson N 1992. Insights into Queensland Aboriginal health status: A retrospective study of 14 communities. Aboriginal and Torres Strait Islander health series no. 6. Canberra: Australian Institute of Health and Welfare.
	10	Health Department of Western Australia 1985. Aboriginal morbidity and mortality in Western Australia. Perth: Health Department of Western Australia.
	11	Honari M 1990. Causes of Aboriginal mortality. In: Gray A (ed). A matter of life and death. Contemporary Aboriginal mortality. Canberra: Aboriginal Studies Press, p.147.
	15	Australian Bureau of Statistics & Australian Institute of Health and Welfare 1999. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples. ABS cat. no. 4704.0. Canberra: ABS.
	21	Australian Bureau of Statistics & Australian Institute of Health and Welfare 2001. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples. ABS cat. no. 4704.0. Canberra: ABS.
	26	Australian Bureau of Statistics 2002. Death 2001. Cat. no. 3302.0. Canberra: ABS.
	30	Australian Institute of Health and Welfare 2002. Life expectancy overview. Canberra: AIHW.
	36	United Nations Development Programme 2004. Human development report 2004. Cultural liberty in today's world. New York: UNDP.
	37	Australian Bureau of Statistics 2003. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples. Canberra: Commonwealth of Australia.
	39	No references to the source of life expectancy estimates are provided but it is stated that they are "...the best that are available from official sources..."
	40	Hill et al. (that is, their own estimates).
	44	Australian Institute of Health and Welfare 2002. Life expectancy overview. Canberra: AIHW.
	48	Hanemann U 2006. Literacy for special target groups: Indigenous peoples. Background paper prepared for the Education for all global monitoring report 2006. Paris: UNESCO.
	51	Australian Bureau of Statistics & Australian Institute of Health and Welfare 2008. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples 2005. ABS cat. no. 4704.0. AIHW cat. no. IHW 21. Canberra: ABS & AIHW.

*(continued)*

**Table A2 (continued): References for source documents of indigenous life expectancy estimates**

Country	No.	Reference
<b>New Zealand</b>	39	Pool DI 1985. Mortality trends and differentials. In: Population of New Zealand. Vol. 1. Country monograph series no. 12. Bangkok: Economic and Social Commission for Asia and the Pacific.
	41	Unpublished data from the National Health Statistics Centre, New Zealand.
	16	Woollard K et al 1993. He Kakano: A handbook of Maori health data. Wellington: TePuniKokiri/Ministry of Maori Development.
	19	Kunitz SJ 1990. Public policy and mortality among indigenous populations. Population and Development Review 16(4):647–672.
	27	Ministry of Health, New Zealand 2003. Our health, our future – HauoraPakari, LoioraRoa – the health of New Zealanders 1999. Wellington: Ministry of Health. Viewed 29 July 2003, < <a href="http://www.moh.govt.nz/moh.nsf/pagesmh/936?Open">www.moh.govt.nz/moh.nsf/pagesmh/936?Open</a> >
	23	Statistics New Zealand 2002. Life expectancy and death rates. < <a href="http://www.stats.govt.nz">www.stats.govt.nz</a> >
	31	Statistics New Zealand 2004. New Zealand life tables 2000–2002. Wellington: Statistics New Zealand.
	34	Stafenogiannis N 2004. Provisional life expectancy data, New Zealand 2001. Wellington: Ministry of Health. & An indication of New Zealander' health 2002. Occasional report no. 1. Wellington: Ministry of Health.
	36	United Nations Development Programme 2004. Human development report 2004. Cultural liberty in today's world. New York: UNDP.
	38	Ajwani S, Blakely T, Robson B, Tobias M & Bonne M 2005. Decades of disparity: Ethnic mortality trends in New Zealand 1980–1999. Wellington: Ministry of Health & University of Otago.
49	Hanemann U 2006. Literacy for special target groups: Indigenous peoples. Background paper prepared for the Education for all global monitoring report 2006. Paris: UNESCO.	

(continued)

**Table A2 (continued): References for source documents of indigenous life expectancy estimates**

Country	No.	Reference
<b>Canada</b>	5	Ministry of National Health and Welfare 1988. Health indicators derived from vital statistics for Status Indian and Canadian populations 1978–1986. Ottawa: MNHW.
	13	Unpublished data from Health and Welfare Canada, Canada.
	17	Canadian Department of Indian Affairs and Northern Development 1997. Basic departmental data, 1996. Ottawa: INAC, pp. 24–26.
	20	Norris MJ 1996. Contemporary demography of Aboriginal peoples in Canada. In: Long D & Dichason OP (eds.). Visions of the heart: Canadian Aboriginal issues. Toronto: Harcourt Brace & Co.
	24	Indian and Northern Affairs Canada 2000. Social development—Health and Social Indicators. Ottawa: INAC.
	28	Health Canada 2003. A statistical profile of the health of First Nations in Canada. Ottawa: Health Canada.
	32	Health Canada 2004. Healthy Canadians: A federal report on comparable health indicators 2002. Ottawa: Health Canada. < <a href="http://www.hc-sc.gc.ca/hcs-sss/pubs/system-regime/2002-fed-comp-indicat/index-eng.php">http://www.hc-sc.gc.ca/hcs-sss/pubs/system-regime/2002-fed-comp-indicat/index-eng.php</a> >.
	36	United Nations Development Programme 2004. Human development report 2004. Cultural liberty in today's world. New York: UNDP.
	39	No references to the source of life expectancy estimates are provided but it is stated that they are "...the best that are available from official sources..."
	42	Martens P, Sanderson D & Jebamani L 2005. Mortality comparisons of First Nations to all other Manitobans. Canadian Journal of Public Health 95:533–38.
	50	Health Canada 2007. First Nations comparable health indicators. Ottawa: Health Canada.
	53	Treasury Board of Canada Secretariat 2005. Canada's performance report 2005: Annex 3: Indicators and additional information. Ottawa: TBCS.

(continued)

**Table A2 (continued): References for source documents of indigenous life expectancy estimates**

Country	No	Reference
<b>United States</b>	6	Indian Health Service 1989. Trends in Indian health 1989: Tables. Rockville: Department of Health and Human Services.
	14	Unpublished data from Indian Health Service.
	18	Woollard K et al 1993. He Kakano: A handbook of Maori health data. Wellington: TePuniKokiri/Ministry of Maori Development.
	21	Jaffe AJ 1992, The first immigrants from Asia: A population history of the North American Indians. New York: Plenum Press.
	25	Indian Health Service 2002. Comprehensive health care program for American Indians and Alaskan Natives. Rockville: Department of Health Services.
	29	Indian Health Service. Trends in Indian health 1998–1999. Rockville: Department of Health and Human Services. Viewed 29 July 2003, < <a href="http://www.ihs.gov/PublicInfo/Publications/trends98/trends98.asp">www.ihs.gov/PublicInfo/Publications/trends98/trends98.asp</a> >.
	33	National Center for Health Statistics 2002. National vital statistics reports. Atlanta: Center for Disease Control.
	35	National Center for Health Statistics 2002. United States life tables 2000. National Vital Statistics Report 51(3).
	39	No references to the source of life expectancy estimates are provided but it is stated that they are "...the best that are available from official sources..."
	43	Indian Health Service. Regional differences in Indian health 2000–2001. Rockville: Department of Health and Human Services.
	47	Center for Disease Control and Prevention 2002. National vital statistics. Atlanta: CDCP.
54	Indian Health Service 2006. Facts on Indian health disparities. Rockville: Department of Health and Human Services.	

**Table A3: Summarising main methods used in publications**

Country, reference period and authors	Method	Indigenous concept	Source population data and quality	Source death data and quality	Main sources of uncertainty and bias	Other key issues	Plausibility of estimates
Australia 1996–2001 ABS(a)	Modified Bhat indirect method (unexplained intercensal treated as migration)	Self-identification	Census population adjusted for those 'not stated' and for indigenous undercount; data quality probably quite good	Registered indigenous deaths, data quality incomplete and changing indigenous identification	Sensitivity to errors in population age distribution, and model failure	Implication of method's assumptions not obvious	At the time widely accepted, now seems low in light of other estimates
Australia 2005–2007 ABS(b)	Deaths adjusted by link to Census and adjusted to post-enumeration survey indigenous identification, then direct	Self-identification	Population from Census adjusted for those 'not stated' and for indigenous undercount (via post-enumeration survey)	Registered indigenous deaths, data quality incomplete and changing indigenous identification	Very high proportion of deaths not matched and high uncertainty in death adjustment factors	Implausible results for some states with good data. Theory good. No numerator/denominator bias	Similar to other recent estimates
Australia 2001–2006 AIHW	Deaths adjusted by linkage to various health data sets, then direct	Self-identification	Population from Census adjusted for those 'not stated' and for indigenous undercount (via post-enumeration survey)	National Morbidity Database indigenous deaths, data quality incomplete and changing indigenous identification	Quite high proportion of deaths not matched, more linked data sets will change results	Possible numerator/denominator bias	Similar to other recent estimates
Australia 1996–2006 Hill et al. & Vos et al.	Indirect Generalised Growth Balance	Self-identification	Unmodified indigenous Census counts; data quality poor but method copes in theory	Registered deaths; data quality poor but method copes in theory	Sensitivity to errors in population age distribution, and model failure	Method complex and implication of method's assumptions not obvious	Similar to other recent estimates

*(continued)*

**Table A3 (continued): Summarising main methods used in publications<sup>(a)</sup>**

Country, reference period and authors	Method	Indigenous concept	Source population data and quality	Source death data and quality	Main sources of uncertainty and bias	Other key issues	Plausibility of estimates
Australia 1996–2001 Kinfu & Taylor	Indirect Preston-Hill	Self-identification	Population from Census adjusted for those 'not stated' and for indigenous undercount (via post-enumeration survey)	National Mortality Database indigenous deaths, data quality incomplete and changing indigenous identification	Probable sensitivity to errors in population age distribution, and model failure	Implication of method's assumptions not obvious	Estimates very close to ABS indirect method for same period but different to indirect Hill et al. method
New Zealand 1981–2004 NZ Census Mortality Study	Probabilistic linkage of death records to Census records over 20 years	Changed over censuses, now 'prioritised' Maori from ethnic	Population from Census adjusted for those 'not stated' and for general undercount estimates (via post-enumeration survey)	Registered Maori deaths; data quality quite good but various concepts sole or prioritised is a source of uncertainty	Variable Maori concepts an issue. Linkage quite good but not perfect	Robustness and sensitivity studied. Adjustments to avoid bias. Best method as time comparisons possible	Current results similar to Statistics New Zealand direct method
New Zealand Statistics NZ	Direct. No adjustments to Maori deaths	Changed over censuses, now 'prioritised' Maori from ethnic	Population from Census adjusted for those 'not stated' and for general undercount estimates (via post-enumeration survey)	Registered Maori deaths; data quality quite good but various concepts sole or prioritised is a source of uncertainty	Act of faith that recording of Maori deaths good and comparable to Census	-	Latest estimates by this approach similar to New Zealand Census Mortality Study
Canada 1983–2003 Inuit area life expectancy	Direct abridged method. Includes all deaths in high Inuit areas	Inuit definition not relevant as all people involved in analysis	Census counts of all residents of defined areas	Registered deaths of all residents of area, even if die outside area.	Incorrect residency of deaths is a possible source of bias. Inuit in area may not represent all Inuit. Bias in population estimates	At best indicative of Inuit life expectancy by allowing for population composition	Estimates quite low. No real comparator

*(continued)*

**Table A3 (continued): Summarising main methods used in publications<sup>(a)</sup>**

Country, reference period and authors	Method	Indigenous concept	Source population data and quality	Source death data and quality	Main sources of uncertainty and bias	Other key issues	Plausibility of estimates
Canada 1991–2001 Census follow-up	Direct method. Linkage of 15% Census sample to deaths, via tax file; transfers Census indigenous identification to deaths	Various Aboriginal groups defined by ancestry in Census	Census counts used as population estimates	Registered deaths. No indigenous identifier on death records.	Failed matched death records large potential source of error. Possibly made worse by using Census counts for population estimates	Life expectancy from 25 years only can be estimated because tax record only for adults. Not done for all indigenous people	Estimates of relative size of gaps for different indigenous groups as expected
Canada 1995–1999 Manitoba First Nations	Direct method. Linking register of First Nations, SVS to deaths; transfers indigenous identification to deaths	Only Treaty or Registered First Nations considered	Population defined by all records in SVS with Manitoban residency	Death data held by Manitoban Centre for Health Policy linked to Indian register (SVS)	More than 30% of Manitoban Indian population not on SVS register		Death records estimated to be under-recorded by 20%
United States 1990–2003 Indian Health Service	Direct method. Registered AI/AN deaths in IHS areas, corrected for supposed undercount and AI/AN population of same areas	American Indian/Alaskan Native	Population defined by AI/AN people resident 'in the vicinity' of IHS clinics—that is, on an IHS register	Deaths of residents of 'IHS areas' registered by state death certificates with AI/AN identification	Huge potential for bias in probably incorrect death adjustment and AI/ANs outside IHS areas may have different life expectancy. Population estimates may be wrong	Little reason to place any confidence in estimates from this method	No plausible comparator methods

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