ABOUT MORTALITY DATA FOR NEW ZEALAND

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<u>**GENERAL**</u>

Important note: the population data for New Zealand are complicated by different levels of data quality by ethnic group (Māori and Non-Māori). Due to recently discovered numerous inconsistencies in the early historical data for Non-Māori, we restricted previously published series of Non-Māori data to the period 1901 onwards (for more details see the 'Data Quality Issues' section below). Starting in 1901, data for the Non-Māori population meet at least minimal data quality standards. However, even the most recent data for the Māori population are affected by a variety of serious problems. For the years 2013 onwards, Statistics New Zealand publishes only rounded figures on deaths. Due to very small numbers and their associated random fluctuations at child- and very old ages, the Non-Māori death counts estimated as the difference between deaths for the total and Māori populations are often implausible. Therefore, the updating of the NZ Non-Māori series is temporarily discontinued.

Taking into account serious data quality issues related to the Māori data and availability of detailed official statistics, the HMD series for New Zealand Total population start from 1948.

Data for the population of New Zealand date back to the 19th century. Population statistics have been collected officially since the country became a Crown Colony in 1840. During the Crown Colony period, the Colonial Secretary was responsible for the compilation of population statistics in New Zealand. From 1853 to 1910, it was the duty of the Registrar-General, and from 1910 onwards, the Government Statistician (Statistics New Zealand, 2004b). Currently, Statistics New Zealand is the main institution responsible for collecting, processing and disseminating statistical data in the country. Primary information about each birth, death and marriage in the territory of New Zealand is administered by the Births, Deaths and Marriages Registry under the Department of Internal Affairs. Original migration data are collected by the New Zealand Customs Service, which forwards this information to Statistics New Zealand for further processing.

The first statistical data for New Zealand were published in 1840 by the Colonial Secretariat under the title "Blue books for the colony of New Zealand" (Statistics New Zealand, 2004b). In 1956, these publications were replaced by the annual (until 1920) volumes of "Statistics of New Zealand". Since 1921, a series of subject statistical reports have been published annually. Aggregated information about births, deaths and population estimates is also available from serial and occasional publications such as "Demographic Trends", "Key Demographic Indicators", "New Zealand Official Yearbook" and others. Since 1871, information about each census has been published in separate volumes (Statistics New Zealand, 2004b). The most recent demographic

data and some longer data series are freely available via the official web site of Statistics New Zealand (http://www.stats.govt.nz).

The first general census of New Zealand took place in 1851, although it excluded the Māori population (Statistics New Zealand, 2001). During the period from 1858 to 1881, censuses were conducted on a triennial basis. Since 1881, censuses have been held every five years (with exceptions in 1931, 1941, 2011). Due to the devastating earthquake in Christchurch on 22 February 2011, the 2011 census was postponed and only took place on the 5th of March, 2013.

The 1858 census marks the first attempt to include the Māori population. However, only limited, aggregate-level information on the Māori population is available from the early censuses. A separate census of the Māori population, which provided more detailed information, was conducted in 1926. Until 1951, separate census questionnaires designed for the Māori population were used. Since 1951, the Māori population has been counted by the general censuses of New Zealand and the practice of separate Māori censuses has been discontinued (Statistics New Zealand, 2001).

There were separate vital registers for the Māori and for the rest of the population (mostly European) until the beginning of the 1960s. The registration system of the Māori population was of much lower quality, so the corresponding historical data on the Māori population are affected by various problems such as the under-registration of births and deaths. Since 1948 (and particularly since 1961), the data for the Māori population have improved. Data for the Non-Māori population are available since 1876 but, as previously mentioned, are not reliable until 1901..

In 1961, the practice of separate birth and death registers for the Māori and the Non-Māori was abolished, and general registers began in 1962. As a consequence, Statistics New Zealand discontinued publishing data separately for the Non-Māori population.

A continuous series of annual population estimates (for the Total, Māori, and Non-Māori populations) date back to 1936. The 1990s mark two significant changes in the population definitions. First, both population estimates and vital statistics for the period beginning in 1991 have been recalculated for the 'usually resident' (*de jure*) population, whereas these data previously covered the *de facto* population.

Second, the definition of ethnicity in the population statistics for New Zealand underwent a major shift at the beginning of the 1990s. Instead of strict definitions of ethnicity based on "degree of blood" or "belonging to a sole ethnic group", a new, more flexible definition (including the possibility of belonging to several ethnic groups) was introduced. These changes made a significant impact on the population estimates, births and deaths and other ethnic-specific statistical indicators for sub-groups of the New Zealand population..

Specific episodes in the demographic history of New Zealand
Mortality in New Zealand was heavily affected by the two World Wars. However, this effect is not reflected in the official statistics because the military population (and combat losses) is excluded during war years.

The influenza epidemic of 1918 caused about 8,500 deaths in New Zealand inducing a large mortality increase during this particular year (Statistics New Zealand, 2004b). Other important events resulting in a significant increase in deaths include: the Hawke's Bay earthquake of 1931, which caused 256 deaths; and the 1979 crash of an Air New Zealand plane on Mount Erebus, Antarctica, causing 257 deaths (Statistics New Zealand, 2004b). The 2011 earthquake caused 185 deaths and massive damages in some areas which was the main reason for postponing the 2011 census to 2013.

Source of Data

The most recent population estimates and birth counts were downloaded from the official website of Statistics New Zealand (http://www.stats.govt.nz). Historical data for the period until 1926 come from Bloomfield (1984). All the remaining published and unpublished demographic data were provided by Statistics New Zealand.

TERRITORIAL COVERAGE

New Zealand consists of two larger Islands and several small islands in the South Pacific. Since the early proclamations in 1840, 1842, and 1847, the small islands were added in 1887, 1901 and 1923. These territorial changes were so small in terms of population size that they do not influence mortality indicators. Therefore, it is not necessary to adjust for these changes. There have been no further territorial changes in New Zealand during the period covered by the data included in the database.

DEATH COUNT DATA

Coverage and completeness

According to Statistics New Zealand, death registration during the most recent decades is complete and the majority of deaths are recorded (Statistics New Zealand, 2004a). By law, all deaths occurring on the territory of New Zealand must be registered within three working days after the burial or cremation' of the body. The funeral director or another person responsible for death notification forwards the notification document to the Births, Deaths and Marriages Registry (under the Department of Internal Affairs). Together with this document, a Medical Certificate of Cause of Death from a physician or coroner is sent to the Registry. A computerized file containing information about each registered death is forwarded to Statistics New Zealand each month. Data are aggregated on a quarterly or annual basis, but only deaths registered in a given year are included into the official death statistics for that year (Statistics New Zealand, 2004a). That is, a death that occurred in 2000 but which was not actually registered until 2001 would be included in the death statistics for 2001.

There is some evidence that death registration was incomplete until the beginning of the 1960s. First of all, concerning Māori deaths, which were counted by a separate register until 1961, some evidence was found by the authors of a possible underestimation at older ages prior to the 1960s (see the 'Data Quality Issues' section

below). In addition, Non-Māori neonatal deaths were seriously underestimated at least until the 1910s (by about 18% in 1876). Deaths of Non-Māori who lived among Māori were also generally unrecorded until the beginning of the 20th century (Statistics New Zealand, 2006). The officially published death counts for the periods around the Boer war (1899-1902), WW1 (1914-1921), and WW2 (1939-1947) cover only the civilian population and do not include the numerous military deaths.

Prior to 1991, data include all deaths that occurred in New Zealand and were registered in New Zealand (i.e. the *de facto* population). Since 1991, data include deaths of New Zealand residents (i.e. the *de jure* population).

According to Ajwani et al. (2003), Māori mortality estimates for the 1980s and early 1990s are significantly affected by a numerator-denominator bias due to differences in how ethnicity was defined by the Death Registry and in the censuses. Information about the degree of blood (the criterion used by the Death Registry until September 1st 1995 was often incomplete as "funeral directors often guessed or assumed the extent of Maori 'blood' or did not complete this section at all" (Pomare et al. 1995; cited in Ajwani et al. 2003). Consequently, there was a relatively high probability of mismatch between the ethnic identification indicated in the death record and self-reported ethnicity given in the corresponding census record. Unfortunately, we have not been able to resolve this inconsistency. Ajwani and his colleagues at the Wellington School of Medicine and Health Sciences (Statistics New Zealand) and Ministry of Health have attempted to avoid numerator-denominator bias by introducing special adjustment ratios (for more details, see Ajwani et al. 2003). Unfortunately, even this study suffers from several methodological constraints.

Specific details
The official death counts are available for single years of age starting in 1948. For the period 1980-2013, death counts by sex, ethnic origin, age, birth cohort, and year of registration were produced from the Births, Deaths and Marriages Registry data (and provided by Statistics New Zealand). For the years 2014 onwards, death counts by sex, ethnic origin (Total population and Māori), age, and year of registration are available only in rounded format. Statistics New Zealand (2022) describes the rounding procedure as the following:

> "Random rounding is used to disguise small counts, but all cells in a table are randomly rounded. Counts that are already a multiple of three are left unchanged. Those not a multiple of three are rounded to one of the two nearest multiples. For example, a one will be rounded to either a zero or a three. Each value in the table is rounded independently. This means counts may not sum to totals, but ensures that published totals are within two of the original number."

The change in definition of ethnicity noted earlier also affected death counts. Prior to September 1st 1995 the definition of Māori and other ethnic groups (by the Death Registry) was based on the degree of blood criterion (e.g. half Māori, full Māori). Since then, ethnic identification of the deceased has relied fully on information provided by the next kin (self-determination concept) (Statistics New Zealand, 2004a). As a consequence, deaths in 1995 are classified by a mixture of the previous and current definitions of ethnicity. An attempt has been made to solve this problem for the Human

Mortality Database (HMD) by introducing a special adjustment factor for deaths (see Appendix II for more details).

However, even after adjusting for the change in the definition of ethnicity, an unexpected increase in Māori deaths is apparent in 1996. A possible explanation is that there may have been a tendency to misreport ethnicity, especially for children.

Due to very low quality of death statistics for the Māori sub-population and the unavailability of data by five-year age groups before 1948, we restrict our data series for the Total and Māori populations to the period starting in 1948. Due to very serious deficiencies of data on deaths before 1901, the series of Non-Māori mortality estimates begin in the year 1901. However, the user should be aware that the HMD estimates for the Non-Māori for the periods 1901-1921 and 1939-1947 should be used with extra caution (see the 'Data Quality Issues' section below).

POPULATION COUNT DATA

Coverage and completeness
The series of Total, Māori and Non-Māori population estimates date back to 1936. Official population estimates for 1936 refer to the population as of December 31st, population estimates for 1937-1990 refer to the average population (the mean of the year ending December 31st), while population estimates for 1991-2014 refer to the population as of June 30th. Data for the period 1936-1990 cover the *de facto* population, whereas data for the years 1991-2021 refer to the 'usually resident' population. To account for the change in population coverage, adjustment factors were used as described in the Methods Protocol (Appendix D).

Māori and Non-Māori populations were counted separately until 1951. Population census data for the Non-Māori population are available from 1858 to 1926 (Bloomfield, 1984). Historical population data on Non-Māori (prior to the 1930s) seem to be unreliable at older ages (see the 'Data Quality Issues' section below).

Official population counts for the First and Second World Wars include the civilian population only. Official population estimates for WW2 (1939-1947) do not account for the large movements of military personnel and war-related deaths. Official population estimates are not available at all for the period around WW1 (1914-1921). Therefore, annual population counts (for Non-Māori population only) were estimated using the HMD methodology (which assumes that migration during the inter-censal periods 1911-1916 and 1916-1921 is distributed uniformly). The newly calculated annual population estimates do not account for very substantial movements of military personnel (40% of males aged 20-44 were mobilized) nor for military deaths and should be treated with caution.

Māori data are of much worse quality than non-Maori data even in the most recent period. First, Statistics New Zealand acknowledges that Māori population data (and, consequently, also total population counts) are incomplete and affected by unde-rregistration of vital events at least until 1936 (possibly even 1961) (Statistics New Zealand, 2004a).

Second, since the removal of the ethnicity questions on New Zealand arrival and departure cards in the mid-1980s, there has been no accurate information on Māori migration (Robson et al., 2001). Thus, the Māori population estimates can not be calculated without using some approximations. Statistics New Zealand (2004a) warns that "all estimates for the Māori ethnic group are supplied only as a guide for research and other analytical purposes". For more details about data problems see the 'Data Quality Issues' section below.

Specific details

The latest population estimates (1991-2021)—recalculated on the basis of the 2001, 2006, 2013, and 2018 censuses—have been adjusted for census undercounts. Population estimates for the periods 2006-2013 and 2014-2017 refer to the inter-censal population estimates revised on the basis of the 2013 and 2018 censuses. According to Statistics New Zealand, the total undercount in the 1981, 1986, and 1991 censuses was about 2% (or about 66,000-70,000 people) (Statistics New Zealand, 1998). Thus, population estimates and census counts may differ substantially for the same year.

The estimated *de facto* population includes all people present in New Zealand and counted by the census (census night population count). This estimate includes visitors from overseas who are counted on the census night but excludes New Zealand residents who are temporarily overseas. The 'usually resident' population is an estimate of all people who usually live in New Zealand, or in an area of New Zealand territory, at a given date. This estimate is based on the census count of the 'usually resident' population, which excludes visitors from overseas, and is adjusted to include residents who are temporarily overseas on the census night as well as residents who are missed or counted more than once by the census (net census undercount). Furthermore, these estimates are adjusted for births, deaths and net migration (arrivals less departures) of residents during the period between the census night and the reference date (Statistics New Zealand, 2004a).

Starting in 1991, official population estimates for the Māori and the Non-Māori populations have also been recalculated according to the 'usually resident' concept. In addition, Māori population estimates have been re-estimated (working backwards from the 2001 census to 1991) using a new definition of ethnicity. Māori and Non-Māori population estimates prior to 1991 use a stricter definition based on self-identification by degree of blood or belonging to a sole ethnicity. Since 1991, official population estimates use a more flexible concept of ethnicity, which is based on self-identification with any ethnic group (with the possibility of belonging to several ethnic groups simultaneously). For more details see Appendix III by Jit Cheung.

Although the population data on Māori (and on Non-Māori) have been classified using the new definition of ethnicity since 1991, data on births and deaths retained the old definition until 1995. In order to assure consistency between the ethnicity-specific data on births, deaths and population estimates, new estimates have been produced here for the Māori population for 1991-1995 based on the older concept of ethnicity. As a result, the series of the Māori and Non-Māori population estimates by the old definition of ethnicity has been extended up to 1995. For more details about all the adjustments related to Māori and Non-Māori data, see Appendix II.

BIRTH COUNT DATA

Coverage and completeness

According to Statistics New Zealand, birth registration is virtually complete with 99.9% of births recorded (Statistics New Zealand, 2004a). Since 1991, birth data refer to births by female New Zealand residents (i.e. *de jure* population). Birth data before 1991 include all births that occurred in New Zealand and were registered in New Zealand (i.e. *de facto* population).

By law, the hospital must notify the Registrar-General within five working days of every live birth or stillbirth (issuing a 'Notification of Birth for Registration'). Within two months after the birth, a 'Birth Registration Form' must be completed and posted to the Births, Deaths and Marriages Registry in the Department of Internal Affairs (Statistics New Zealand, 2004a). The Birth Certificate is issued on the basis of the latter form.

Computerized information including both notifications of births and birth registration forms is sent to Statistics New Zealand once a month. Data are aggregated on a quarterly or annual basis, but only births registered in a given year (even if they actually occurred in an earlier year) are included into the official birth statistics for that year (Statistics New Zealand, 2004a). For more details see Appendix III by Jit Cheung.

Basic registration of births began in 1848 and was made compulsory in 1855. A more comprehensive registration system started in 1875. Registration of stillbirths became compulsory in 1919 only. Due to the poor quality of Māori statistics, Māori (and, consequently, Total population) births may have been underreported or misreported until 1961 (when the separate vital registration system for Māori was abolished) (Statistics New Zealand, 2004a). Pool (1967) noted several years in the 1940s when birthdates of Māori newborns were severely misreported. For example, because a universal system of family benefits was introduced in 1946, there was a tendency to register Māori children as being born during this particular year (although they were born earlier). The New Zealand Official Yearbook 1947–1949 reported that "Of the 5776 Māori births registered during 1946 no fewer than 1447 or 25% had occurred before 1945 - i.e. over a year before registration" (Statistics New Zealand, 2004a). Therefore, we decided to use the official data on Māori and Total births only for the period 1948 onwards.

Historical data on Non-Māori births are also problematic, especially before the 1910s (Statistics New Zealand, 2006). First, there was an underestimation of neonatal deaths, which was quite significant (about 18% in 1876) until the beginning of the 20th century. Second, some Māori births were registered as Non-Māori. Last, births of Non-Māori who lived among Māori were also generally unrecorded (Statistics New Zealand, 2006).

Specific details

As in the case of deaths, a major change in the definition of ethnicity used on birth certificates occurred in 1995. Prior to September 1st 1995, the definition of Māori and other ethnic groups was based on identification by the degree of blood criterion (e.g. half Māori, full Māori). Since September 1s 1995, ethnic identification relies on information provided by the parent(s) of the newborn (self-determination concept) (Statistics New Zealand, 2004a). As a consequence, births for the year 1995 are

classified by a mixture of the previous and current definitions of ethnicity. However, we found that such change had only a negligible impact on the birth rates. Therefore, by contrast with our treatment of deaths, we decided not to use additional correction factor in this case.

DATA QUALITY ISSUES

Table 1. A short summary of data quality issues relevant to Non-Māori, Māori, and Total population statistics

Period	Non-Māori	Māori	Total
1871-1900	1. Notable undercount of neonatal deaths 2. Undercount of deaths occurring among Non-Māori residing among Māori 3. Misclassification of ethnicity in census, birth, and death data 4. Very implausibly low mortality rates at old ages (partly due to very small death and population counts at ages above 80) 5. Population censuses are affected by undercount and age misreporting problems 6. Highly volatile in- and out-migration patterns during inter-censal periods 7. Exclusion of war-related deaths and military population (during the Boer war in 1899-1902)		
1914-1921	8. Exclusion of numerous war-related deaths and military population 9. Implausibly low mortality rates at old ages for some years (possibly due to incomplete registration)		
1939-1947	10. Exclusion of numerous war-related deaths and military population	1. Incomplete registration of births and deaths 2. Implausibly low mortality rates at old ages	1. Exclusion of numerous war-related deaths and military population 2. Very low quality of data for the Māori sub-population possibly

			affecting the quality of data for the total population.
1948-1960		4. Implausibly low mortality rates at old ages	
1991-1995	11. New definition of ethnicity introduced in the 1991 census, while a similar definition change in death and birth records occurred on September 1st 1995 only. Lower quality and inconsistent data for the Māori population also affecting the series for the Non-Māori population for this period.	4. New definition of ethnicity introduced in the 1991 census, while a similar definition change in death and birth records occurred on September 1ST 1995 only. Statistics New Zealand produced series of population estimates based on the old definition of Māori but on indirect information.	
1996-2014	12. Due to the differences in the definition of ethnicity, the series for the period 1996-2014 are not fully comparable to the series for the period before 1996.	5. Due to the differences in the definition of ethnicity, the series for the period 1996-2014 are not fully comparable to the series for the period before 1996. 6. Mortality at older ages is volatile and implausibly low for some years	
2014-2021	13. Age-specific deaths are only available as rounded numbers (multiple of 3).		

1. Problems with Non-Māori old age mortality estimates before 1901.

Prior to 1901, the death rates at older ages estimated using the HMD methods protocole are implausibly low, and consequently, life expectancy estimates are implausibly high for those surviving to those older ages. For example, among non-Māori females in 1877, e_{80} is estimated at 14.4 years. Life expectancies in 1881 and 1891 published by Preston, Keyftiz, and Schoen (1972) also show very large discrepancies at advanced ages (see table 2).

Table 2. Life expectancy in New Zealand (non-Maori) in 1881, 1891, and 1901

Year	Age	Preston et al. (1972)		HMD		Difference	
		Males	Females	Males	Females	Males	Females
1881	0	53.34	56.80	53.87	57.33	0.54	0.53
	30	36.50	38.90	37.21	39.45	0.70	0.56
	60	15.88	17.00	16.88	17.69	1.00	0.69
	80	6.14	6.19	8.90	8.11	2.76	1.92
1891	0	54.50	57.73	54.87	57.65	0.37	-0.08
	30	36.91	38.91	37.11	38.61	0.20	-0.30
	60	14.51	16.86	14.79	16.37	0.28	-0.49
	80	6.22	10.86	7.05	7.00	0.84	-3.86

These discrepancies result from the fact that the original raw data for this historical period are available in an aggregate format only (i.e., five-year age groups with an open age interval at 80+), and also that there are very few deaths at very old ages. For example, among females aged 80+, there were only 16 deaths in 1877 and 29 deaths in 1878. Unfortunately, the application of the current Human Mortality Database (HMD) procedure for splitting deaths in open age intervals combined with other HMD methods for estimating the mortality surface produce implausible estimates of old age mortality for this particular period.

For small populations, the number of deaths at advanced ages is likely to be small and highly variable, particularly during early historical periods. Large fluctuations in death counts for the open age interval create several problems for estimating mortality using the standard HMD methods. The nature of these problems can be described in more detail as follows. First, the annual number of deaths for the open age interval 80+ tends to be unexpectedly low for some years. Second, as a consequence of applying the extinct cohort method to estimate population size at ages 80+, a small number of deaths[1] is observed during some years in combination with a larger number of deaths in subsequent years, leading to the overestimation of the population at higher ages. Consequently, mortality tends to be underestimated because the numerator, i.e. the deaths, is too small and/or the denominator, i.e. population exposure, is too large.

This problem can be solved by changing the parameters of the model for splitting deaths in the open age interval together with increasing the age interval for the smoothing of death rates (e.g. from 80+ to 70+). In other words, such cases require special procedures for splitting deaths in the open age interval. Thus, the problem results in part from the application of a uniform set of methods across all countries, which helps ensure that HMD estimates are comparable across time and across space, but which present problems in some special cases.

2. Quality of historical data on Non-Māori population counts.
There is evidence that New Zealand censuses conducted before 1926 were affected by undercount and age misreporting problems (Pool, 1973).

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[1] This may result from an undercount of deaths as well as from real fluctuations in the observed data.

The estimation of annual population counts for the period before 1901 is further complicated by a highly irregular pattern of migration. It is known that strikingly high immigration caused unprecedented rates of population increase in New Zealand (the population size of New Zealand increased about ten times between 1860 and 1891). However, during some years (e.g. in the 1880s) net-migration became negative. Such significant out-migration waves were caused by severe economic crises (Statistics New Zealand, 2006). Due to volatile international migration and very small population numbers, the application of the HMD methods to compute inter-censal population estimates for the period before 1901 is too restrictive and may lead to serious biases (the inter-censal survival method described in the *Methods Protocol* assumes that migration is distributed evenly between the two census points).

The estimation of annual Non-Māori population counts for the period around WW1 (1914-1921) is also problematic. We estimated annual population counts for Non-Māori population using the HMD methodology (which assumes that migration during the inter-censal periods 1911-1916 and 1916-1921 is uniformly distributed). The newly calculated annual population estimates do not account for very substantial movements of military personnel (40% of males aged 20-44 were mobilized) nor for military deaths and should be treated with much caution. The official population estimates for the period around WW2 (1939-1947) also cover the civilian population only.

3. Quality of the recent Māori and Non-Māori population estimates.
More recent Māori and Non-Māori population estimates are affected by different problems. The first problem results from the approximation procedures used by Statistics New Zealand because of the absence of ethnic-specific migration data for the period after 1986. Statistics New Zealand statisticians assume that the current age pattern of Māori migration is the same as it was during the period 1982-1986. A second problem relates to the Māori population estimates for the period 1991-1995. Because births and deaths were classified based on the old definition of Māori ethnicity for this period, Statistics New Zealand estimated births and deaths based on the new definition of Māori using only indirect or additional information on births and deaths (for more details and the HMD solution to this problem, see Appendix II and the 'Population Count Data' section).

Another problem with the quality of population estimates concerns the rounding procedures used by Statistics New Zealand. Due to small population numbers at older ages (especially among the Māori population), rounding to the nearest ten can produce some distortions or unexpected fluctuations in mortality rates at these ages.

4. Under-reporting or misreporting of vital events
Under-reporting or misreporting of vital events is especially relevant for the Māori population. Pool (1973) suggests that registration of vital events for the Māori population was very incomplete at least until the mid-1930s. Statistics New Zealand applied smoothing procedures to Māori deaths for the period until 1947, making age-specific mortality data for Māori (and Total population) even more uncertain.

Due to the poor quality of Māori statistics, Māori (and, consequently, Total population) births may be underreported or misreported until 1961 (when the separate vital

registration system for the Māori was abolished) (Statistics New Zealand, 2004a). Pool (1967) noted several years in the 1940s when birthdates of Māori newborns were extremely misreported. For example, because a universal system of family benefits was introduced in 1946, there was a tendency to declare Māori children as being born during this particular year (although they were in fact born earlier).

Data for neonatal deaths and live births for the Non-Māori population are also incomplete, at least until 1901. In addition, some Non-Māori births and deaths for the 19th century actually include Māori deaths and births. During the same period, Non-Māori births and deaths were generally not registered for the Non-Māori residing in the Māori settlements (Statistics New Zealand, 2006). Finally, numerous war-related deaths during the Boer, WW1, and WW2 wars are excluded from the official statistics.

Substantially higher life expectancy at older ages for the Māori and Non-Māori populations compared with the corresponding higher quality Swedish data may indicate death undercount problems (Figures 1 and 2). In the case of the Māori, mortality estimates at older ages also seem to be very unreliable even for some of the most recent years (Figure 2). Among the Non-Māori population such problems are much less evident and mostly concern the period before 1920.

Data quality problems related to the change in the definition of ethnicity in 1995 are discussed in the Appendix II.

Figure 1. Trends in life expectancy at age 80 among New Zealand Māori and Swedish males.

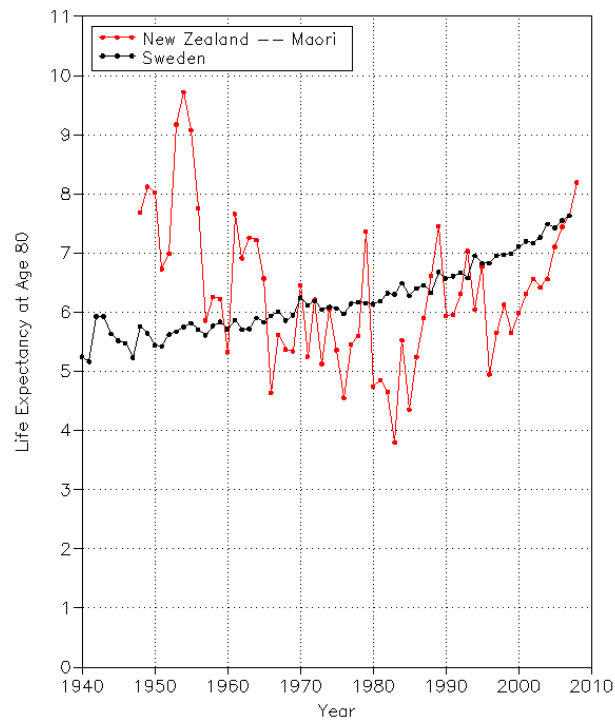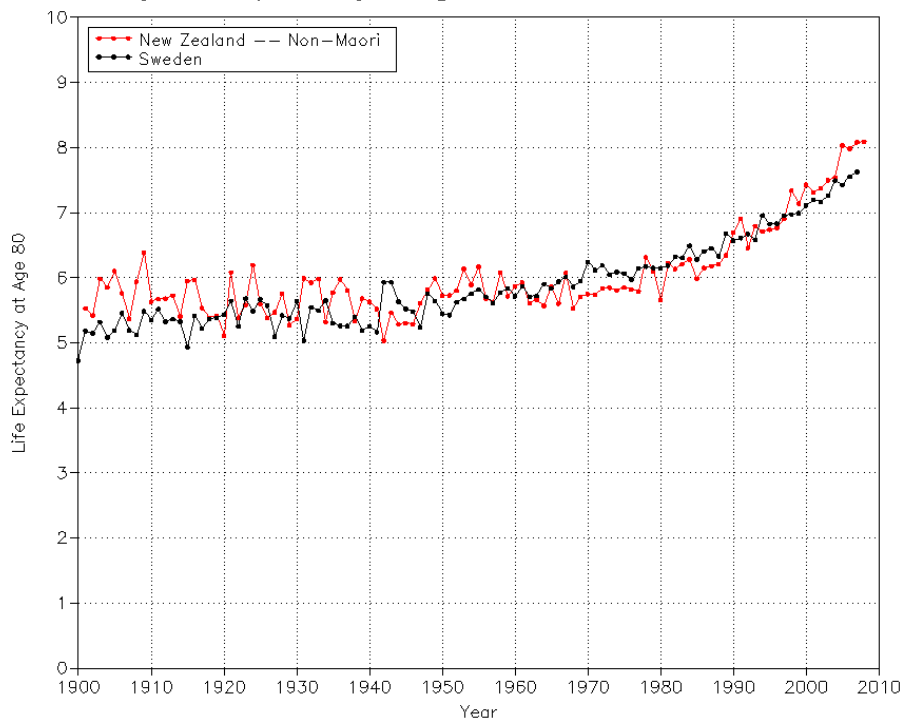External Plausibility: Life Expectancy at Age 80, Males, New Zealand ——Maori

Figure 2. Trends in life expectancy at age 80 among New Zealand Non-Māori and Swedish males.

External Plausibility: Life Expectancy at Age 80, Males, New Zealand ——Non—Maori

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REVISION HISTORY

Changes with the May 2022 revision:
Life tables: All life tables have been recalculated using a modified methods protocol. The revised protocol (Version 6) includes two changes: 1) a more precise way to calculate a0, the mean age at death for children dying during the first year of life and 2) the use of birth-by-month data (where and when available) to more accurately estimate population exposures.

These changes have been implemented simultaneously for ALL HMD series/countries. For more details about these changes, see the revised Methods Protocol (at http://www.mortality.org/Public/Docs/MethodsProtocol.pdf), particularly section 7.1 on Period life tables and section 6 and Appendix E, on death rates. The life tables calculated under the prior methods (Version 5) remain available at v5.mortality.org but they have not been, and will not be, updated.

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APPENDIX 1: DESCRIPTION OF DATA USED FOR LEXIS DATABASE

DEATHS

Period	Type of Data	Age Grouping	Comments	RefCode†
1948	Annual number of deaths for the *de facto* population by sex and age	0,1,2, … , 100+		8
1949-1979	Annual number of deaths for the *de facto* population by sex and age	0,1,2, … , max age		8
1980-1990	Annual number of deaths for the *de facto* population by sex, age, and year of birth	0,1,2,…, max age		9
1991-2013	Annual number of deaths for the 'usually resident' (*de jure*) population by sex, age, and year of birth	0,1,2,…, max age		9, 10, 11, 12, 13, 15, 20
2014-2021	Annual number of deaths for the 'usually resident' (*de jure*) population by sex and age	0,1,2,…,100+	Rounded data	25

POPULATION

Period	Type of Data	Age Grouping	Comments	RefCode†
1948-1990	Mid-year population estimates ("mean year ended December 31st") for the *de facto* population.	0, 1, 2, …89, 90+		5
1991-2017	Population estimates as of June 30th for the 'usually resident' (*de jure*) population	0, 1, 2, …89, 90+	Inter-censal population estimates.	16, 18, 24
2018-2021	Population estimates as of June 30th for the 'usually resident' (*de jure*) population	0, 1, 2, …89, 90+	Post-censal population estimates	24

BIRTHS

Period	Type of Data	Comments	RefCode†
1948-1990	Annual counts of live births by sex for the 'actually present' (*de facto*) population		1
1991-2021	Annual counts of live births by sex for the 'usually resident' (*de jure*) population		1, 2, 3, 4, 17, 19, 22

† The reference code is used in the raw data files (Input Database) to link data with sources.

BIRTHS BY MONTH

Type of data: Annual live birth counts by month

Period covered: 1980-2020.

RefCode(s): 23.

APPENDIX II:

CHANGES IN THE DEFINITION OF ETHNICITY IN NEW ZEALAND: ADJUSTMENTS TO RAW POPULATION DATA AND DEATH COUNTS

By Dmitri Jdanov and Domantas Jasilionis   Last updated: 06 July 2010

Changes in the census ethnicity questions in the 1980s and 1990s

The definition of Māori used on census questionnaires changed over time. The earliest definitions, based on "belonging to the Māori race" or "quantum of Māori blood" (proportion of descent criterion), were used until the 1986 census. Starting with the 1986 census, ethnicity was identified according to a more flexible concept of self-identification with any ethnic group. However, ethnic-specific population estimates counted as Māori only those people who indicated solely that ethnicity (on the census form). Until 1990, the definition of ethnicity used for estimating the Māori population seem to have been rather comparable, as there were no obvious discontinuities in the trends for the Māori population during the 1980s.

A new definition of ethnicity was introduced in the 1991 census. For the first time, the Māori ethnic group also included those who indicated more than one ethnicity in the census. Such flexibility, together with changes in the questions about ethnicity, resulted in a substantial increase in people identifying themselves as Māori. Each of the three censuses in 1991, 1996, and 2001 used different wordings for the ethnicity questions (based on self-identification). New population estimates were recalculated backwards from the census of 2001 to 1991 (the wording of the ethnicity question in these two censuses being more or less comparable), replacing population estimates based on the census 1996.

Changes in the identification of ethnicity in birth, death and migration records

While a new flexible concept of ethnicity was introduced as early as in 1986 for population counts, a similar reform in the definition of ethnicity used for birth and death certificates was not introduced until 1995. Interestingly, the new concept of ethnicity was applied not at the beginning of the year but on September 1st. Until that date, the old concept (based on quantum of Māori blood) was used.

Information on the ethnicity of in-migrants has not been collected since 1987. Statistics New Zealand assumes that Māori net migration follows the same pattern as during the period 1982-1986. This assumption affects the quality of Māori population estimates as well.

Implications of changes in official definitions of ethnicity on demographic data

Because the new definition of ethnicity was not used for birth and death certificates until September 1995 (more than four years after the change was introduced for population estimates), it was not possible to calculate ethnic-specific demographic

indicators for 1991-1995. Statistics New Zealand used indirect or additional information on births and deaths to calculate revised birth and death counts (based on the new definition of ethnicity) for the Māori population during this period. For example, births were redefined as Māori if there was any indication of Māori ethnicity (based on ethnicity of the parents or other indicators of ethnicity). Māori deaths for the period 1991-1995 based on the 'new' concept were derived from death rates that were used for the 1996-based Māori population projections (Statistics New Zealand, 2004a). These revised birth and death counts have never been published, and it was therefore not possible to use these approximations for the HMD either.

Consistency between the definitions of ethnicity used for population estimates and for births and deaths is shown in Figure 3.

Figure 3. Changes in definitions of the Māori ethnic group
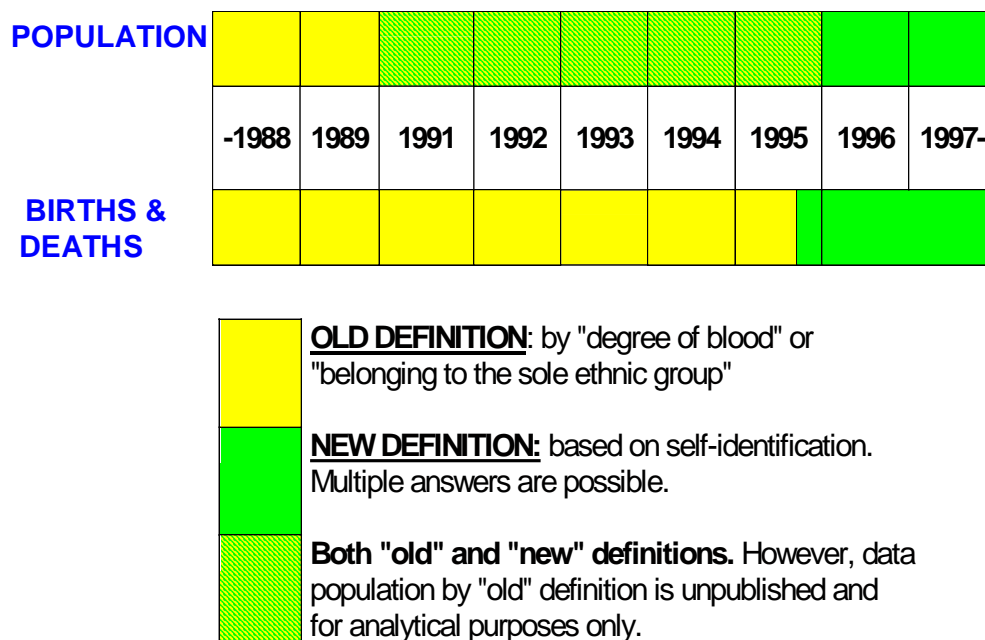
If the official published population estimates and deaths for the period 1991-1995 are used, the life expectancy of Māori will be over-estimated due to the discrepancyt between the concepts of ethnicity used to classify data on deaths and on population (Figure 4).

Statistics New Zealand has attempted to solve the discrepancy and has produced Māori population estimates according to the 'old' definition for the period 1991-1995. However, these data are also imperfect and have never been published. It was possible to use them only indirectly for the HMD estimates of population, births and deaths according to the 'old' definition of Māori.

Figure 4. Life expectancy at birth of the Māori population calculated from the official (unadjusted) data.
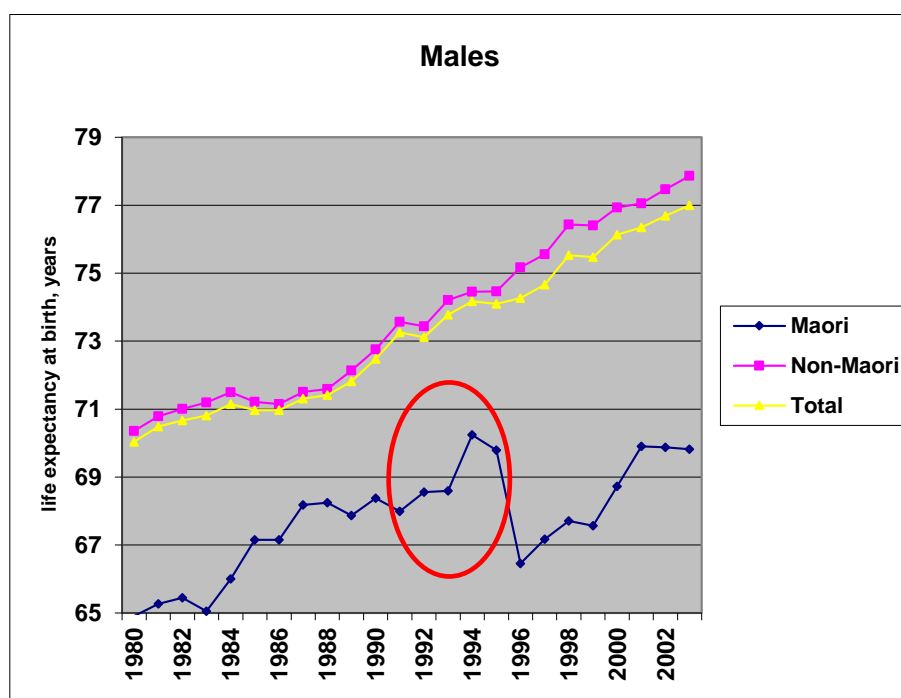
The most serious problem with the ethnic-specific data concerns the year 1995. Because the new definition of ethnicity took effect on September 1st, data on Māori births and deaths for this year are classified by a mixture of the narrower 'old' and the more flexible 'new' concepts of ethnicity. Therefore, although Māori population estimates based on the 'old' definition are available, their use would over-estimate mortality and fertility due to the more flexible concept of ethnicity used for the birth and death certificates in the latter part of 1995. However, we found that the change in the definition had only a very minor impact on the birth rates. Therefore, by contrast with what was done for the deaths, we decided not to use additional correction factors in this case.

Solution to the problems related to the changes in definitions of Māori

In the HMD, changes in the definition of ethnicity are dealt with as changes in population coverage. Although such changes are not due to territorial changes, they can be treated as such in order to make appropriate adjustments to the formulas. Thus, a standard procedure was applied, as described in the *Methods protocol* (see Appendix D) to derive new intercensal population estimates for 1991-1995. For this, it was also necessary to calculate adjustment factors for the population (V_x).

The ratio between the Māori population as defined by the new concept and the old one is treated as if it were a ratio between populations after and before a territorial change (i.e. V_x adjustment factor). More specifically:

$$V(x,1996) = \frac{P^{new}(x,1996)}{P^{old}(x,1996)} \quad , \tag{A2.2}$$

where $P^{new}(x,1996)$ is the Māori population at age x on January 1st 1996 based on the new concept and $P^{old}(x,1996)$ is the Māori population at age x on January 1st 1996 based on the old definition.

It was also necessary to adjust the number of deaths in 1995 to account for the excess due to the new definition of ethnicity introduced in September. Therefore, an additional territorial adjustment factor for deaths (not specified in the *Methods protocol*) has been calculated according to the following formula:

$$Rd(x,1995) = \frac{\overline{M}(x,1994,1996)}{M(x,1995)} \; , \qquad\qquad \text{(A2.3)}$$

where $M(x,1995)$ is the actual age-specific mortality rate for the Māori in 1995 (where deaths represent a mixture of 'old' and 'new' definitions and population estimates have been adjusted to correspond to the 'old' definition) and $\overline{M}(x,1994,1996)$ is the average of the age-specific mortality rates for the Māori in 1994 and 1996. Applying this ratio to the original Māori death count in 1995 ($D(x,1995)$) produces the approximate number of deaths ($\hat{D}(x,1995)$) based on the 'old' definition:

$$\hat{D}(x,1995) = Rd(x,1995) \cdot D(x,1995) \; . \qquad\qquad \text{(A2.4).}$$

In other words, the excess deaths resulting from the introduction of the new definition of ethnicity are excluded so that both deaths and population for 1995 are based on the same 'old' definition. The result of this procedure for males is shown in Figure 5.

After calculating the adjustment factors and correcting the number of deaths for 1995, the intercensal method for calculation of population estimates was applied for the years 1991 to 1996 (see Appendix D of the *Methods Protocol*). The result is a new continuous series of Māori indicators, which are calculated using adjusted ethnic-specific death and population data for 1991-1995. A comparison of trends in life expectancy at birth using the original raw data and the adjusted figures is presented in Figure 6. We can see that, after adjustment, the large increases in life expectancy at birth in the 1991-1995 period have almost disappeared. The corresponding figures for the Non-Māori population can easily be derived using adjusted Māori and total population data.

Unfortunately, we were not able to solve the numerator-denominator bias arising from possible misreporting of ethnicity in death records, therefore even adjusted data on Māori and Non-Māori should be treated with caution.

Figure 5. Trends in Māori deaths before and after application of the adjustment factor
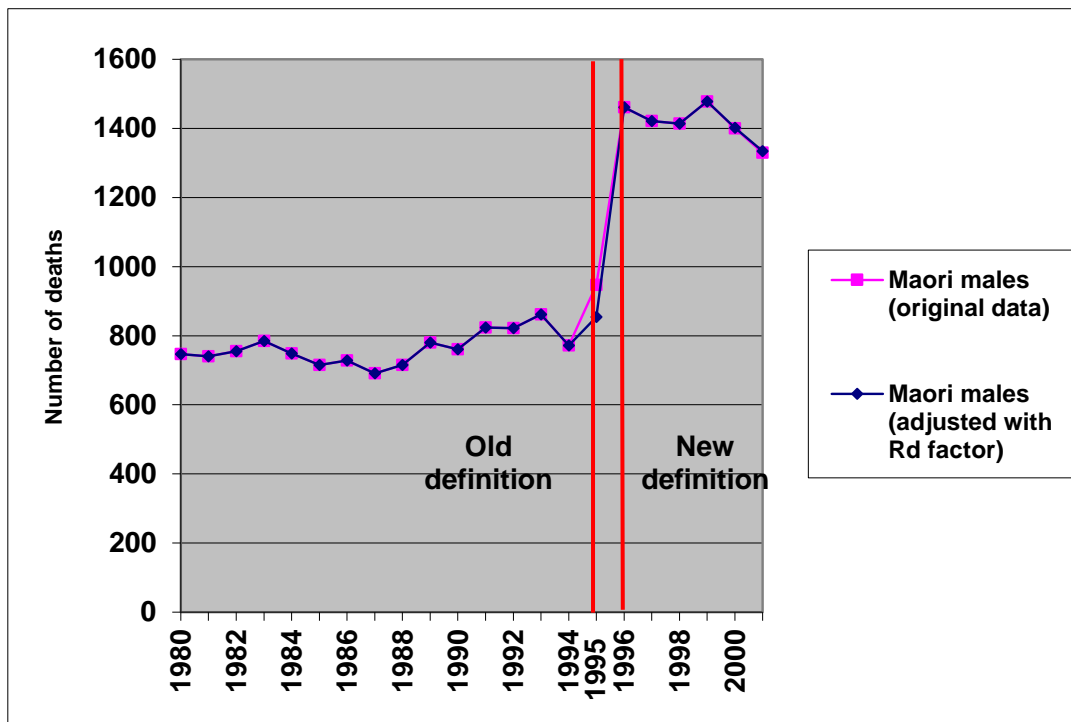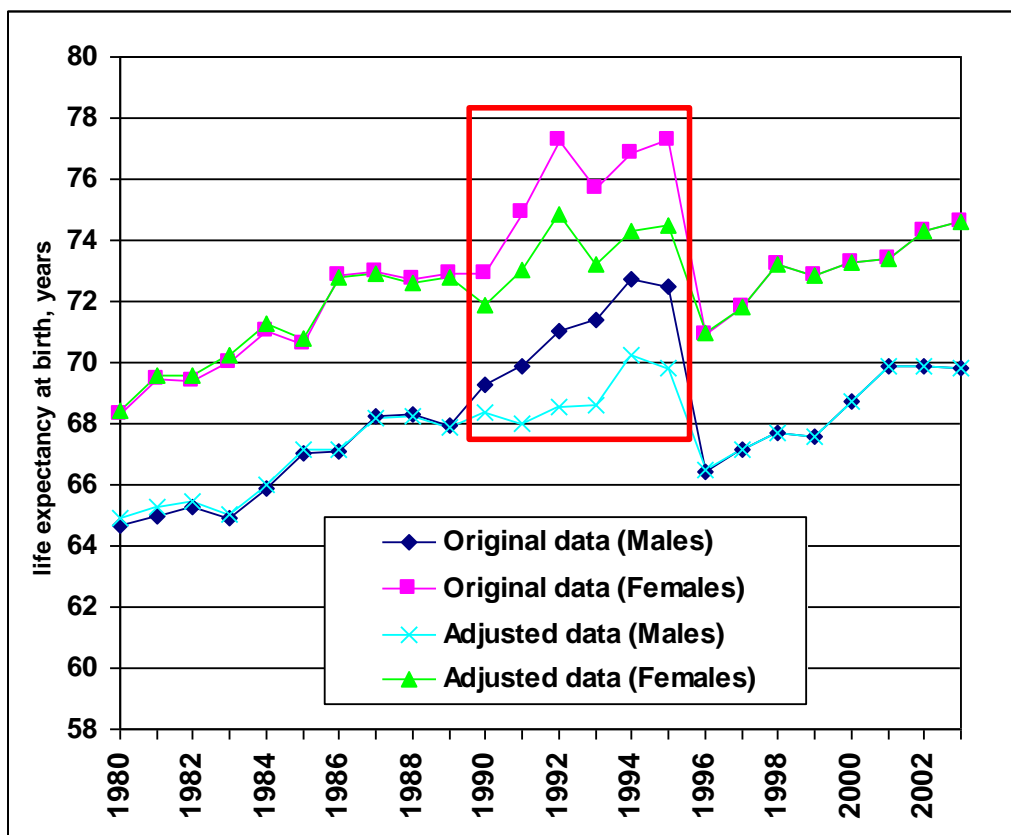

Figure 6. Life expectancy at birth of the Māori population calculated from the official (unadjusted) and from the adjusted data.

APPENDIX III:

COMMENTS ON THE QUALITY ISSUES RELEVANT TO THE ETHNIC-SPECIFIC POPULATION DATA

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Introduction

Increasing ethnic diversity is a demographic reality in New Zealand and around the world. This worldwide phenomenon is a point of celebration for societies as well as among research communities. At the same time methodological issues around ethnic definition, data collection and measurement are becoming more complicated. In the New Zealand context, changes in the official definition of ethnicity reflect not only changes in administrative practice, but more importantly changes in society's understanding, perceptions and empathy to race and ethnic issues. These latter changes were driven by social, economic, political, demographic and other forces.

In this appendix more detailed comments are provided on the ethnic dimension in New Zealand population and vital statistics.

Current situation

In New Zealand the issues of defining ethnicity and making comparative assessments along the ethnic dimension are particularly pertinent. Historically, the New Zealand population is made up of two major ethnic groups: the indigenous Māori population and the more dominant European population. Over time these two ethnic populations have undergone different demographic and health transitions, and, as a result, have attained distinctively different age structures and mortality profiles. Currently, these two major ethnic groups occupy opposing ends of the socio-economic spectrum. Health and demographic analyses that fail to disaggregate trends and patterns by ethnicity will mask considerable disparities between the ethnic groups.

Moreover, New Zealand's ethnicity make-up has also greatly diversified over the last few decades, largely as a result of international migration. At the latest 2001 Census, the fastest growing Asian population has overtaken Pacific peoples as the third largest major ethnic group in the country. Moreover, the number of people who identified with two or more ethnic groups has also increased.

Table 1 shows the ethnic mix at the 2001 Census by the five major ethnic groups derived by Statistics New Zealand, by a single ethnic group only (those who identify with only the ethnic group reported in Table 1 and none other) and by multiple ethnicities (those who identify with the ethnic group reported in Table 1 plus at least one of the other four major ethnic groups).

The difference between the number of people reporting one and only one ethnic group and the total corresponds to the number of people identifying with multiple ethnic groups. For example, 2.610 million people (or 70.0% of the total population) reported one European ethnic group only; an additional 0.258 million people (or 6.9% of the total) reported one European ethnicity and one or more of the other ethnic groups, bringing the European total (the sum of those reporting one and only one European ethnic group and those reporting several ethnicities including European) to 2.868 million people (or 76.9% of the total population). Thus numbers in the 'Total responses' column are not mutually exclusive and add up to more than the grand total.

<u>Table 1</u>. New Zealand 2001 Census resident population by major ethnic group

	Number of people		Percentage of total	
	Single ethnic group only	Total responses	Single ethnic group only	Total responses
European	2,610,408	2,868,009	70.0%	76.9%
Māori	294,726	526,281	7.9%	14.1%
Pacific People	166,056	231,801	4.5%	6.2%
Asian	213,582	237,459	5.7%	6.4%
Other	19,533	24,924	0.5%	0.7%
Not stated	-	143,598	-	3.8%
Total	3,730,332			

Source: Statistics New Zealand

Accompanying the increasing ethnic diversity are changes in social perception towards the issue of ethnicity, as reflected by the increasing proportion of people identifying with multiple ethnic groups and by changes in the official definitions in successive censuses and vital statistics collections. The most significant change in Māori ethnic definition occurred in the 1980s, with a switch from a biological concept of blood quantum to a self-identified social concept of cultural affiliation. The process of change can be described as an on-going experiment, in a continuous search for the optimal combination of concept and phraseology.

For simplicity of presentations, hereafter the term 'Non-Māori' is used to refer to '*all persons in the population who do not identify as Māori in the total response to the question on ethnicity*'.

Remarks on ethnic population data

Prior to the 1976 census, Māori ethnicity was defined in New Zealand censuses as "persons of half or more Māori blood". In the 1976 census, an additional question was added that asked respondents whether they claimed Māori descent, even if they gave a negative response to the question on degree of Māori blood. The net effect of this change appeared to be an over-reporting of people claiming half or more Māori blood (Pool and Pole, 1987). The question on Māori descent was dropped in the 1981

census, but was picked up again as a separate ancestry and descent question in 1991, 1996 and 2001. Meanwhile, a self-identified, cultural affiliation definition of ethnicity and a hierarchical procedure of ethnicity coding were introduced in the 1986 census, which were also used in the three subsequent censuses.

Under the new system, respondents were asked to check as many circles as needed to show to which ethnic group(s) they belong. When New Zealand Māori is one of the groups reported, the person is assigned to New Zealand Māori, otherwise a series of procedures are used to assign that person to another ethnic group. Further problems arising from this change result from category jumping, where individuals may change ethnic identity between data collection operation.

The series of changes in census ethnicity definition and coding practices render longitudinal analysis of Māori ethnic data over time difficult. The implications of this problem extend beyond the census data, affecting comparability between the census and other data sources (see below). The effects on Non-Māori population data, however, are greatly mitigated by this group's much larger size.

Remarks on ethnic death data

Prior to September 1995, a biological definition of ethnicity was used on the death registration form, asking about the "degree of Māori or Pacific Islander blood" of the deceased's parents. A new form was introduced on September 1st 1995, with the question on ethnicity being the same as the self-identified, cultural affiliation definition used in the 1996 census. This change improved the comparability between census and death data, but it also introduced a definitional discrepancy in the mortality historical time series. Again this is an issue affecting Māori data disproportionately.

Ethnic death data for the 1995 calendar year was adversely affected by the definitional change coupled with a possible administrative lag in its full implementation around the country. Data for the last quarter were of particularly questionable quality.

A number of potential problems also exist in the analysis of historical ethnic mortality statistics in New Zealand. Historically, the ethnicity of the deceased was often determined by an observer, usually the funeral director. The family of the deceased was rarely consulted (see Kilgour and Keefe, 1992). Often, ethnic identification became based on skin colour, a questionable identification technique. Furthermore, non-responses to the ethnicity question on the death registration form were subsequently coded as 'Other', or 'Non-Māori', and this could have lead to considerable under-reporting for Māori.

The inconsistency in the timing of changes in the definition of ethnicity in the census and vital statistics generated severe biases in the estimation of Māori and Pacific death rates and, to a lesser extent, birth rates, known as the 'numerator-denominator bias'. In a major study, the New Zealand Census-Mortality Study (NZCMS), Ajwani *et al.* (2003) quantify the numerator-denominator bias by using probabilistic matching of ethnicity entries on death records in the three years following the Census to the Census unit record. It was found that the numerator-denominator bias negatively affected Māori and Pacific ethnic groups strongly in the 1980s and early 1990s, particularly in the younger age groups. The situation has improved markedly in the

more recent years. The NZCMS calculated adjusters for Māori, Pacific, and Non-Māori Non-Pacific ethnic death statistics for different periods of time. Most adjusters converge to one for the more recent years, pointing to the disappearance of the numerator-denominator bias.

Age misreporting, particularly at the very old age of 85 years and over, may be another source of concern. Problems arise when age recording relies on secondhand reporting and can not be verified by birth certificates. This is particularly true for older Māori since birth registrations for the Māori prior to 1948 were unsatisfactory, as well perhaps as for a small number of immigrants included in the Non-Māori population coming from societies in which birth registration was incomplete. The study by Kannisto (1994) suggests that Non-Māori mortality data at older ages is of generally good quality. The issue of age mis-reporting among Non-Māori is of minor concern in comparison with that for Māori.

Remarks on ethnic birth data

Currently Statistics New Zealand defines a live birth as "The birth of a child who breathes or shows any other evidence of life, such as beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached."

As with deaths, birth registration practices have changed in 1996 from a biologically-based ethnic definition to one based on self-identification of cultural affiliation. The current registration form asks the ethnicity of the mother, the father (where applicable) and the child using the same question as in the census. All responses are treated as valid, and no attempt is made to match the ethnicity of the child with that of the parents. In cases where ethnic details are missing for a child, the child is assigned to all of the ethnic groups of the parents, restricted to a maximum of three ethnicities following the prioritizing procedure used in the census.

The new ethnicity question may result in more Māori births than under the old regime. Accordingly, changes in ethnic-specific patterns may reflect a definitional change rather than an actual change in ethnic-specific fertility.

There have been several other noticeable disruptions to ethnic birth data time series. The universal family benefit program introduced in 1946 affecting primarily low-income families was responsible for a surge of late registration of births among these families. Māori and Pacific families were over-represented in the low-income category. More recently, the Births and Deaths Registration Act of 1995 redefined and broadened slightly what constitutes a stillbirth. Under the new definition if a child born dead either weighs 400g or more, or the gestation has lasted for 21 weeks or longer, then the death is to be registered as a stillbirth. Before this Act, a stillbirth was defined as the birth of a child born dead after 28 weeks of pregnancy.