New Zealand Population Review 29(2):107-138.

A Cohort History of Mortality in New Zealand

IAN POOL*
JIT CHEUNG

Abstract

This paper uses the generational life tables to track historical mortality experience for New Zealand Pakeha and Māori. The key research questions we seek to explore concern with why was Pakeha life expectation so high so early, and why did this survival advantage disappeared by the mid 20th century and what has happened since? For the Māori population what was the impact of contact on Māori mortality, what were the changes that have occurred and why, and what has happened to Māori mortality recently? A key finding from the cohort mortality analysis is that gains in survivorship have momentum effects that propel this advantage forward as survivors move up through the age-groups. That said, however, periods of gain may be followed later by cohort deterioration occurring among the same generations later in their life-cycle, and even by further cycles of reprise and deterioration. These cycles of gain, deterioration, reprise etc are more evident for males, and particularly for Māori. Policy implications of these findings are discussed.

This paper maps the history of mortality in New Zealand over the last 100-200 years. It is heavily empirical, yet it also addresses major theoretical and policy issues. Its starting point is the observation that there are still people living amongst us in New Zealand who were born in the 19th century, at a time when life expectation for a Pakeha child was less than 60 years, and for a Māori was below 25 years. That did not, of course, mean that these were average ages at death, or that these figures represented upper limits of longevity. Then as now some persons died at "grand old ages", but the key point was that the force of mortality, the ages at which high proportions of the population fail to survive, was very different.

According to the generation life-tables we have estimated,[1] when Dame Whina Cooper, who lived into her nineties, was born, 37 per cent of her cohort would not have survived to their first birthday (see Table 1). In fact,

* Population Studies Centre, University of Waikato. Email: pool@waikato.ac.nz.
Ministry of Health, Wellington. Email: Jit_Cheung@moh.govt.nz.

fewer than 50 per cent of these young Māori girls would have reached their 10th birthday and thus only a minority would have reached adulthood. Those who passed their 40th birthday would, however, have had in front of them the same number of years of longevity that the cohort had had at birth – about 25 years. And a very small minority would expect to reach very old ages (see also Pool 1991). This is what we call the force of mortality at the outset of an epidemiological transition. In contrast, Pakeha were already well into an epidemiological transition, and thus more than 85 per cent of Pakeha girls born at this time would not only reach adulthood, but would survive to the end of their reproductive span. Yet, their expectation of additional years of life at menopause was then not dramatically different from that of their Māori counterparts.

Table 1: The Māori and Non-Māori generations born in the early 1890s: Survivors to a given age, and *cohort* life expectations at given ages

	Maori		Non-Maori	
	Males	Females	Males	Females
Life-expectation at given ages in years (e_x)				
At birth	29.6	25.9	59.6	64.8
At 45 years	22.8	22.4	27.9	32.2
Number of original cohort of 100,000 surviving to 1, 10 and 45 years				
Reaching 1	62,913	60,627	97,409	97,476
Reaching 10	57,177	46,673	87,564	89,329
Reaching 45	36,818	30,666	77,457	80,164
Probability of surviving from exact age x to x+n				
Birth to 10	0.572	0.467	0.876	0.893
10-45 years	0.644	0.657	0.885	0.897

Sources: see Appendices.
Note: Cohort tables normally give higher e_x values than do synthetic tables of the corresponding birth periods because of improvements in survivorship over the cohorts' life-spans.

In the 1890s, at birth the gap in life expectation for females between Pakeha and Māori girls was 39 years; at 45 it had dropped to 10. For males the comparable differences in years were 30 down to only five. Equally well gaps in the probabilities of surviving diminished significantly over the life-span (ages 0-10 years, as against 10-45).

In contrast, for both Māori and Pakeha cohorts born in the second half of the 20th century, the majority could expect to reach their sixties or beyond. This is the force of mortality at the last stages of an epidemiological transition (Pool 1994), at least as human populations have experienced up till now. Later in this paper we will ask whether past experience is a guide to the future, a question that has enormous implications for health services and policies.

The passage through this epidemiological transition (the term of Omran 1982), particularly of the sort that Māori achieved, is very complex. It involves, *inter alia*,

- a shift in the force of mortality by age, as we have just described,
- a shift from the predominance of communicable disease mortality to non-communicable, a point we will cover here in passing, and
- a shift from lower levels of female life-expectation between the two genders to lower levels of male (Stolnitz 1955-56),[2] a transition that Māori went through between 1945 and the 1950s, at a time when mortality data were of sufficiently good quality for us to have confidence in this observation (here we are talking about the reporting of deaths from all causes, not the certification of their causes). In the late 19th century, at reproductive ages Pakeha females had had higher risks of mortality than males, across a wide range of causes and not just maternal mortality.

The determinants of the different aspects of the epidemiological transition are also complex. Bio-medical technologies became really critical for public health only after World War II, when service methods allowed the newly developed antibiotics and chemotherapeutics, and vaccines, to be delivered to mass populations. Thus we must search for other factors before this time. These include general social and economic change. From a public health standpoint, community health programmes (of the model suggested in the Alma Ata, WHO Assembly 1978), and the promulgation and application of a wide range of health regulations relating to sanitation, hygiene, food preparation and patient care, and the improved delivery of health services were all important. The link to other aspects of public policy is also important.

As much of the Pakeha transition had occurred before World War II, we must look beyond bio-medical explanations. Moreover, between the 1890s and 1945 Māori life expectation at birth (e_0) had edged up from the low 20s to 48 years, so again we have to go beyond bio-medical explanations. Māori life expectancies then increased rapidly between World War II and the late 1950s. It would be easy to suggest bio-medical explanations for this improvement, and certainly they played a role, but with 50 per cent of the decline coming from tuberculosis alone (75 per cent for adults), a disease for which no simple bio-medical explanation applies for that era, we have to look elsewhere. Finally, observations from the period 1960 into the late 1980s on a slowing of improvements for both Māori and Pakeha, including clear evidence of cohort deterioration, require explanations that are also outside the purely bio-medical framework.

Why is the History of Mortality Important for Present Day Public Health Concerns?

This could be seen as academic, an interesting history but of little relevance for contemporary public health. Such a viewpoint would be badly mistaken, for the following reasons.

As an individual carries into later stages of their life cycles health problems to which they were exposed at younger ages, so too do cohorts carry forward what they have experienced over their life cycles. These include exposure to risks of mortality, their access to health care, and changes in policy environments over their life spans. In sum what we have outlined earlier. For example, even assuming that care was of equal quality, compared with their Pakeha peers cohorts of post-menopausal Māori women still carry with them the extra wear and tear, the physiological burden of childbearing (Waldron 1982), of the several more pregnancies they will have experienced. To take another case, classical cause-specific cohort studies on tuberculosis for populations in which declines did not result from access to powerful antibiotics, show a "recrudescence" at older ages.

From a public health policy standpoint, the most important questions relate to the future of longevity – the "burden of disease" is a sub-plot to this. Debate revolves around different postulates on this: whether it will extend and to what age, indeed whether there are limits at all, whether the gaps between premature and much later deaths in any cohort will compress or extend, and then the related question of whether extensions in longevity (Oeppen and Vaupel 2002) will be accompanied by a longer or shorter duration in ill-health. Each postulate has a different implication for public health. To provide accurate projections of different trends cohort analyses of mortality are needed, and particularly generation life-tables (Cheung 1999; 2001).

Less directly, for both health trends and service programmes this history may provide information and lessons that are very relevant to the formulation of public health policy and services. We will illustrate this by referring to Māori at the dawn of the 20th century.

The remainder of this paper is a history that draws on cohort life tables, reproduced in the appendices, for Non-Māori (Appendix A) and Māori (Appendix B), on recent synthetic tables (Appendix C). Appendix D relates to the construction of the life-tables and to problems with data sources, especially Maori historically and recently. To organise this history it attempts to respond to six questions relating to:

i. The very early achievement of high levels of life-expectation by Non-Māori – Pakeha women were probably the first population anywhere to see e_0 reaching 60 years.
ii. The carrying forward of this advantage into the twentieth century, and the subsequent cohort deterioration (defined later).
iii. Then the recent gains in Pakeha life-expectation.
iv. The decline in Māori life expectation from levels probably among the highest anywhere in 1769 (e_0 = 30-32 years) to very low levels (<25) in the 1890s.
v. The improvements in e_0 for Māori between the 1890s and 1910 (from <25 years to perhaps 35).
vi. The gaps between Māori and Pakeha that still exist.

Question 1: Why was Pakeha life expectation so high so early?

Addressing a more theoretical debate, Oeppen and Vaupel (2002) used New Zealand in the early 20th century as a case-study to argue that observed e_0 might already exceed limits to longevity being posited by the pundits of any period. They then raised the question why New Zealand should have been so advantaged, and the present authors responded to this in an invited paper at the Max Planck Institute, Germany, in September 2002 (Pool and Cheung 2002). We briefly summarise our results here.

Firstly, before one can ask "why", it is necessary to verify whether the data were satisfactory. Moreover, given that the official tables of the day excluded Māori, we asked what would have been the effect on the overall levels if Māori had been included.

Sceats and Pool (1985a) had argued that under-registration of Pakeha neonatal deaths occurred in the late 19th century. But by comparing observed values for the life-table function p_x (probability of surviving from exact age x to x+n) with model life tables we were able to show that if this "had occurred in the 1880s and 1890s, it would have been very slight. At ${}_1p_0$ in 1874… there does, however, seem to be an indication of the effects of under-registration at infancy" (Pool and Cheung 2002:13). This actually strengthens later arguments below about the carry-over of this advantage for cohorts into the 20th century.

The exclusion of Māori does have some effect despite the fact that Māori were only 9 per cent of the total population in the 1880s. The e_0 for New Zealand as a whole drops from 56 years (Pakeha alone) to 51 years (Total), the same as Norway's at that time, but e_{20}, e_{40} and e_{60} fall below the values for Norway. If Māori are excluded, values for Pakeha at younger ages are well above those for Norway and Sweden, but older ages (eg. e_{40}) fall below. Thus it seems that adult New Zealanders faced relative, albeit minor, disadvantage by comparison with some northern European populations, a trend that continues in 20th century tables (Pool and Cheung 2002:14-15).

Turning to "why" Pakeha were advantaged in this way, one has to dismiss bio-medical explanations as major factors, and even public health can not be cited (as is clearly documented in MacLean 1963). We point instead to several underlying factors (drawn principally from Pool and Cheung 2002).

The economic factors favoured Pakeha. Despite the "long depression" from the late 1870s to the early 1890s, the economy "started from a high level relative to other countries, and maintained a high level…" (Hawke 1985:77). Lifestyles and living conditions may have been the best anywhere. There was a surplus of meat proteins in the diet (a good factor in those days), population densities even in urban areas were low, housing was detached, typically with their own gardens, the climate was temperate and most people could garden all year. Public policy, particularly under the Seddon government, reinforced all of these effects.

But there were also other factors that had more direct effects on health (Pool and Cheung 2002). The first was the migration process and the second was decline in fertility.

In the 1880s and 1890s the younger Pakeha population was mainly born in the colony with all the advantages that this bestowed; the older population by contrast was immigrant in origin arriving in the peak flows of the late 1860s and 1870s and carrying with them the cohort morbidity histories of Europe. Migration then dried up in the long depression until another significant inflow especially from Australia in the early 1900s. This explains why e_0, affected by both childhood and adulthood patterns were above Nordic levels, yet e_x for adult ages alone were below. The migrant selection processes of the Vogel government (including for "phthisis") in the late 1860s and 1870s, when some of our highest inflows ever occurred, may have had a minor effect, compounded by "six months on a leaky boat".

The greatest improvements in Pakeha survivorship in the late 19th century occurring from 1876 to 1896, in fact the most rapid at these ages at any time in their history, were at childhood ages, before any specialist paediatric health programmes, such as Plunket, were established. For boys, for example, only 82 per cent of the cohort born in the early 1870s would reach 10 years; by 1896 it was 88 per cent. From 1896 improvements were much slower; the proportion of the 1911-16 cohort of boys reaching 10 years had increased only to 91 per cent. These changes at infancy and childhood had such important overall effects that they produced an aberrant pattern of mortality decline for Pakeha. Other industrialised countries saw more rapid improvements after 1900, whereas for New Zealand they had occurred before 1900.

The improvements in survivorship at infancy and childhood in the absence of either a bio-medical or public health explanation is easily explained. There was a very rapid fertility decline at this time, from almost seven births per woman to three, and again there was not a technological reason for change. Instead, a very significant shift in marriage patterns for women took place, from early and almost universal to late and with increased spinster-hood rates (Sceats and Pool 1985b). The decrease in family sizes would have affected cross-sibling infection levels, overcrowding in households especially in bedrooms, the capacity of families to feed and clothe children, and a decline in the need to pass childcare of younger siblings from parents to older siblings. These impacts show up in the cause- and age-specific mortality rates across almost every group of causes, in data terms most robustly for accidental death rates that drop very rapidly. Interestingly, this fertility decline also seems to have determined a sex crossover for mortality from a range of causes at the reproductive ages. In 1876, males had higher survivorship at these ages, but by 1916 the situation had totally reversed (Pool 1994).

We have discussed in some detail the very early period for Pakeha because trends established then laid down everything that has happened since. In essence the major advances in survivorship had already been achieved by early in the 20th century.

Question 2: Why did this advantage for Pakeha continue into the 20th century, and why then did it disappear?

These issues can be dealt with quite summarily using data in Appendix A. Public health reforms came in a burst in the early 1900s, with the establishment of a Department of Health, and the passing of some important regulations, and again in some areas in the 1920s and early 1930s (eg. maternity hospital standards, and maternal and child health services). But an important factor was endogenous to cohorts, and came from the changes noted just above. The gains to cohorts when at young ages in the late 19th century produced a momentum effect that resulted in improved survivorship when they reached older ages. As shown above, by 1900 far more children in each cohort were surviving to 10 years of age, and then with some further reinforcement by period improvements this meant far more persons in the cohort were still alive at 50 years. The key factor, however, was to survive to age 10 (Pool and Cheung 2002).

From the birth cohorts of the 1920s, however, cohort deterioration set in across a range of adult ages, particularly for males. This can be seen in the cohort tables. Thus for several decades across some active ages succeeding cohorts' survivorship probabilities were lower than had been the rates for their predecessors (Pool 1983; Cheung 1999). It could have been due to the effects of improved regimes of maternal and child health care introduced in the inter-war decades of the 20th century. This may have permitted the survival of high-risk babies, who would have died under previous regimes, to survive to become at risk or "frail" adults. An alternative explanation is linked to period effects related to the lifestyles that cohorts adopted later in life (Pool 1983) – this comment refers, of course, to the exposure of cohorts born before the war to the lifestyles, behaviours and environments prevalent in the 1950s and 1960s. Changes in all of these, for factors such as the prevalence of smoking, have been significant in recent decades.

Regardless, the force of mortality had clearly shifted upwards from children to the middle aged, and by the post-war period was having an impact at pre-retirement and retirement ages. For male cohorts, 67 per cent born in 1871 would reach 50 years, and 32 per cent 75; 82 per cent of boys born in 1911 reached 50 years, and 41 per cent 75 years; but over 90 per cent born in 1951 reached 50, and at least three-quarters will have a 75th birthday.

Question 3: Has cohort deterioration for Pakeha become less evident, has there been a reprise, and what are the implications?[3]

Systematic deterioration was observed at an even younger adult ages for the cohorts of 1951-56. Indeed declines in inter-cohort survivorship probabilities among males at young adulthood were particularly marked. The fact that this same cohort had also benefited handsomely from a prolonged period of substantial improvements in infant and early childhood survivorship almost suggests that the deterioration at reproductive ages is a compensating mechanism for the enhanced survivorship at younger ages. We should also note that the pace of decline in infant and early childhood mortality has dropped off since what was achieved by the 1951-56 cohort.

When middle-aged, however, the 1951-56 cohort had recovered sufficiently (as observed from its trends in the 1990s) to retain a level of mortality below that of its predecessors. This thus opens up interesting questions: do gains observed over the more recent periods represent real gains in survivorship, or are they simply an effect of cohorts regaining their trajectories? Is the period improvement the start of a longer-term trend, or merely a temporary phenomenon?

Projections of mortality constructed by Cheung (1999) address this. He shows that for younger cohorts survivorship improvements continue well into old ages. More importantly, for the cohort of 1951-56 over 81 per cent of men and 88 per cent of women will reach 70 years. Thus the force of mortality is clearly not just at retirement, but even at much older ages. This point raises what might be seen as among the most important questions, discussed above in the second section of this paper, for population health in the developed countries: the question of compression vs extension. That is, whether the force of mortality has shifted up sufficiently, so that the great majority of deaths are increasingly concentrated in a narrower age range, or whether the force of mortality is continuing its upward shift leading to a broadening of the age-at-death distribution at the advanced ages.

These questions are not merely academic, for the issue of mortality compression has far-reaching policy implications. The eventual outcome will determine the size and the mix of the future older population, and, through interactions with morbidity, will define the health status and health needs of future populations. The lack of a robust knowledge on mortality in New Zealand limits speculation about this last point.

An analysis of mortality focusing on the second part of the 20th century carried out by Cheung (1999) has found some weak evidence to support the compression hypothesis. The issue becomes even less clear-cut when viewing the data from a cohort perspective. Considerable variations, at times deterioration, in cohort mortality patterns underline marked inter-cohort differentials coming from accumulated exposure to risk, and in terms of carrying risk at earlier ages forward to later ages. This latter finding indicates that life expectancy is not yet approaching its biological limit, and some further increases can be realistically expected, albeit at a decelerating pace.

Question 4: What was the impact of contact on Māori mortality levels?

The skeletal evidence for pre-contact Māori is really our only source of information on possible levels of mortality at the time of Cook. One must note that the data are at best fragmentary, and with very few specimens.[4] But they suggest that Māori e_0 may have been of the order of 32+ years at birth at that time. In the paleo-demographic literature this level is high. It approximates the figure for the British aristocracy at that time, and also the level for Sweden -- the nation probably with the highest expectancy at that era. It was above the level for England as a whole, or for other European countries such as Italy or France. From what can be deduced retrospectively about this geographically isolated population, Maori were not exposed to the "apocalyptic" diseases such as the plague, cholera or smallpox,[5] but absent too were tuberculosis, influenza and the so-called acute infectious childhood disorders, such as measles (Pool 1991:chapt 3).

Māori mortality increased after contact, and especially after 1840, to reach extreme levels in the last 40 years of the 19th century (see above). From then on life-expectation improved in the early 1900s significantly to achieve, and then pass, pre-contact levels. The reasons why this path was followed has been fully documented elsewhere (Pool 1991:chapts 4 and 5), and thus can be briefly summarised here.

Clearly Māori had no natural immunity to the diseases that were introduced. The sailors arriving here came from some of the most squalid urban environments of Europe and the Americas (Crosby 1986:232; Pool 1991:62), and thus brought with them the wide spectrum of virulent diseases that would have been prevalent in their home ports. Even the settlers would have been previously exposed, and would have carried with them respiratory and other acute infectious diseases. The "childhood" disorders wreaked particular havoc – the first nationwide measles epidemic, in 1854, probably killed about seven percent of all Māori, across all ages, as no one had immunity except a few in the far south previously exposed in a local outbreak. As epidemics occurred more frequently, say the next national measles epidemic in the early 1870s, those previously exposed had some immunity and death tolls were high among the young, but overall they were lower than they had been in 1854. Once introduced the chronic infectious disorder tuberculosis was particularly virulent, and this was reinforced, especially after the 1860s, by malnutrition and extremely poor living conditions attendant upon land loss. It should be noted that levels of direct mortality resulting from the so-called "Musket Wars" before Waitangi, and even from the "Land Wars" of the 1840s and 1860s, were a minor factor. In contrast, the indirect effects of war, especially of the Land Wars, would have been far more important, and in the latter case were reinforced and extended over time because of raupatu.

But for diseases to be successfully introduced and spread, especially to some parts of the interior of the North Island where large populations lived, there had to be several pre-conditions. The early frequent contacts of Europeans were with coastal iwi in a relatively few locations; this then changed. The immigrant population had to grow so as to provide a sufficient "reservoir of infection", and large numbers of settlers had to have contact with significant components of the Māori population. The Treaty of Waitangi permitted contact to increase. But even then the greatest and longest impacts came only through what Belich calls "swamping", with the huge inflows of Pakeha in the late 1860s and 1870s. For this to occur land had to be available for settlement, the key development mechanism of New Zealand's most explicit ever population policy: the *Immigration and Public Works Act* (1870). Land availability, in its turn, depended on breaching the Treaty through the application of raupatu to opponents to the crown, and through land sales, at first mainly in the South Island. But later these actions shifted more and more to the heavily settled accessible areas of the North, and eventually to the remote Tuhoe, Ngati Tuwharetoa and Ngati Maniapoto heartlands (Pool 2002). Major sales were still being forced through the courts in the early 20th century.

One can not over-emphasise how significant for Māori health was land loss through raupatu, land sales that were essentially forced, and the taking of land say for public works, enforced by court action and other ostensibly legal processes. This direct taking of the major economic resource of Māori reinforced other factors so as to maintain and entrench high levels of mortality for Māori at the very time when Pakeha rates were dropping rapidly. Although raupatu was limited in duration and geographical coverage, it obviously had severe immediate effects on iwi such as Waikato and Taranaki, particularly when linked to a "scorched earth" campaign, as in the Urewera in 1868, and it was not just confined to iwi who had fought the crown. Some iwi subject to raupatu also suffered loss through forced land sales – Taranaki was an extreme case of this.

The other major cause of land loss was the sales that occurred throughout New Zealand, over a very long duration, that were far from benign and thus whose long-term impact was arguably more severe than raupatu. Court-driven land loss processes had both immediate and long-term effects. Immediate in that all members of hapu (even babies) owning lands brought under the jurisdiction of the courts had to attend hearings or forego all rights, often travelling long distances to do so, and living near the courts under crowded, unhygienic and squalid conditions. Some hearings became infamous for the loss of life of Māori participants. Moreover, the process severely disrupted their normal social and economic life, in particular causing major declines in the production of food.

Even more serious were the long-term effects of raupatu and land sales. Māori had to restructure entirely their economic and social lives, as land loss meant that they no longer had recourse to the previous extensive use of land to gather food and for mahinga kai. They also lost their most fertile land on which kumara production and other gardening had occurred, and often they lost access to moana kai resources. Finally, many were uprooted and had to migrate.

This all produced malnutrition-infection cycles, the effects of which can be indirectly documented through indicators relating to dependent children, the most vulnerable sub-population, and one whose survivorship is taken internationally as a sensitive indicator of social development. Systematically then, iwi by iwi, region by region, in the years following major losses through raupatu or land sales, child survivorship (measured by a very crude index) decreased. It then picked up again only when Māori had been able to find some mechanism for coping with the loss of their economic base. Some iwi, notably Tuhoe, even went through two cycles: raupatu → decreased survivorship → a start towards recuperation → land sales forced through the courts → once again decreased survivorship (Pool 1991:chapts 4 and 5).

Question 5: When and why did changes occur for Māori?

By the early 1890s Sir James Carroll, a Māori minister in Seddon's cabinet holding a key post, Lands and Forests, discerned a demographic reprise occurring, and recruited Māori students to the Young Māori Party to help forge a strong renaissance. By then immunity to introduced diseases was increasing, while communities were finding mechanisms by which they could cope with land loss (Pool 1991: chapts 4 and 5).

But there was another factor. The passing of the *Public Health Act* (1900), and the establishment of a Department of Health – the provision of services had been chaotic prior to that (MacLean 1963) – saw the creation of a Division of Māori Hygiene staffed by Māori medical graduates who had also been mentored by Carroll. In turn they launched a public health campaign, devised by them, and with all the features that 70 years later were to be heralded as an inspired new initiative by the Alma Ata Assembly of WHO. Critical to this were community involvement and empowerment (eg. the *Māori Council's Act*, popularly termed *Te Pire Kiore*) and the implementation of basic modes of sanitation, often introduced by appealing to iwi lore.

Between the 1890s and the early 1900s there was, in fact, a rapid improvement in Māori life expectation, from 23-25 years to 30-35 years over a decade.[6] Unfortunately, this momentum was not maintained, and e_0 increased gradually by only 12 years over the next four decades (1945, e_0 = 49 years among males and 48 years among females).

During and after World War II came perhaps the proudest moment in the history of public health in New Zealand, when health policy was nested into social policy. The fundamental principles for both emanated from the 1938 *Social Security Act*, that ensured equal provision of services to both Māori and Pakeha. Moreover, the newly introduced armoury of bio-medical technologies often reinforced this, but the real factor was public health, in the broad sense of that term (Pool 1994).

As was noted earlier, it was the rapid decline in the tuberculosis death rate that was the most remarkable aspect of this. In his fascinating pioneer public health study on the East Coast, Dr Turbott (1935) had identified the prevalence of tuberculosis among Māori and had analysed its co-variates, while Edson wrote a seminal paper on this in the *New Zealand Medical Journal*, identifying the importance of the problem (1943). Armed with this evidence-base, 10 per cent of Māori (and nurses, the other population deemed to be most at risk) were x-rayed annually by mobile x-ray units. Sufferers were sent to sanatoria, while the social welfare system moved in to help their families find adequate housing, normally a state rental, and other financial and nutritional support. Cohort analyses show a radical decline for every single cohort, a very different trajectory from the much slower decrease of Pakeha. Yet it is worth noting that, apart from population screening and diagnosis, this was not due to high technology bio-medical interventions: an appropriate anti-biotic became available only at the end of the period of most rapid decline (1945-56). By the 1970s, however, residual cohort effects were showing up at older ages, perhaps because of the methods used for treatment, or perhaps because of a failure to maintain screening programmes (Pool 1985, 1994).

As had been the case in the first documented Pakeha mortality decline discussed earlier, much of the total decline for Māori during the period

1945-66 came at the youngest ages. Decreases at 0-4 years constituted 60 per cent of the male total, and 46 per cent of the female. In short, by the end of this period the force of mortality had shifted up from childhood, whereas fewer changes had occurred at older ages, particularly for men. Indeed, at older ages for men there was deterioration, whereas for women there were consistent gains at all ages, and a sex crossover occurred. That said, women still faced major health problems. For example, male rates of coronary heart disease were closer to Pakeha. Although Māori female rates were below those of Māori men, they were still "extraordinarily high by world standards…" (Beaglehole 1977)

This is seen in the e_x in the following table. By way of comparison data are also shown for e_0 for Pakeha. This was clearly a period in which some of the "gaps" were partly, but not completely, closed.

Table 2: Life-expectation (years) at selected ages, Māori, 1945-66

	Birth	15	30	45	60	Non-Māori at birth
Males						
1946	49	44	35	23	14	67
1966	61	50	36	23	13	69
Females						
1946	48	42	32	22	13	71
1966	65	52	38	25	15	75

At this point it is worth reflecting on Māori health issues until say the 1980s, for these are still having a residual impact on recent trends, particularly because of the latent effects on cohorts being carried forward as each generation ages, as is seen in the data in Appendix B. Our argument here is that, when looking at the present, one can not ignore the history of cohorts.

Two points are pertinent. Firstly, for numerous Māori male cohorts, from those born in the 1890s to the 1920s, and again for those born in the period of rapid mortality decline after World War II, improvements in survivorship often went forward in bursts. There would be a gain, and then not just a period of standing still but Māori cohorts would suffer survivorship deterioration. In the 1960s the effects of this were so marked that the Māori male e_0 actually decreased slightly. This would be followed by a second period of gain, and this then led the population into the 1990s, when further deterioration seems to have occurred (see below next section).

Secondly, for Māori women it is useful to go back to Beaglehole's comment quoted above to posit a public health issue that we feel is not discussed enough. Clearly living conditions, smoking levels, lifestyles and diet must play some role for a cluster of factors, including obesity, diabetes and cardiovascular mortality. But we would add another: the physiological burden of childbearing. All Māori female cohorts born up to the early 1950s will have differed markedly from their Pakeha peers in this regard. Some cohorts now at older ages will have had over six live births, and thus on average, allowing for foetal loss, perhaps eight, or even nine, pregnancies, often under less than optimal conditions. While fertility has dropped very significantly, to just over two births per woman, the locus of Māori reproduction is still disproportionately at youngest ages that might be more at risk of negative effects.

Question 6: What has happened to Māori mortality recently?

This then sets the scene for the last decade or so. What is remarkable is the evidence of very recent cohort deterioration for numerous cohorts, male and female, across a broad range of ages. There could be three explanations for this trend. (We draw here on recent synthetic tables, see Appendix D.)

i. It could be artefactual, a result of shifts in definition of ethnicity affecting, in different ways at different times, both numerators and denominators.
ii. It could be a function of the carrying forward from the past of cohort "frailties", to use the technical term.
iii. It could be the impacts of radical restructuring on Māori. Other work at the Population Studies Centre (Honey 2001) has pointed to the disparate impact of job loss on the Māori workforce. Not only was there a net loss during 1986-96, but when demographic supply is taken into account the impacts are seen to be far worse. Other work still being completed also estimates regional differences in "discouraged worker" effects, and related factors.

Turning to these postulates, the artefactual explanation may seem immediately appealing, as it is an issue that has been widely discussed in policy and research circles. In part, we have obviated this because we have used averages over several years, thus dampening fluctuations, but also producing rates that cover periods with different data collection protocols. But on closer examination it may even prove to be counterfactual.

The recent cohort deterioration was between 1991 and 1996, and was typically followed by a reprise by 2001. For the oldest male cohorts, the most recent cycle of deterioration was already evident as early as 1981. Yet the argument about data quality has been that, by comparison with the censuses of 1991 and 2001, the census of 1996 may have inflated the size of the Māori population, thereby inflating denominators and artefactually reducing mortality rates. In contrast, we have shown that they increased – by comparison with immediately preceding cohort, the survivorship probabilities had actually decreased in our generation tables. Vital registration changes were introduced in 1995, becoming effective in 1996. Thus both our 1996 average figure and that for 2001 will have been governed by the same protocol.

There is another issue here that has been seldom discussed: displacement of registration of Pacific Island deaths. If the life-tables for this population in the early 1990s were taken literally, they would have had the highest levels of life expectation in the world. In contrast, in the late 1990s levels appear much more reasonable, close to Māori. Thus Pacific island deaths must have been displaced elsewhere, most likely classified as Māori (Pool 1991).

To analyse the effects of this the authors used the Pacific Island death rates for the late 1990s applying them to the population at that time. Differences between these "expected" Pacific Island deaths and that used in the original Pacific Island life table calculations (the "observed") were significant, at more than 300 deaths among males and more than 200 among females. These differences were then subtracted from the Māori tables. The results are a six years increase in life expectancy at birth for Māori males and a four years increase in Māori females in the early 1990s. These Māori expectancies seem too high. Thus a second simulation was carried out allocating only half of the differences in Pacific Island deaths as wrongly registered as Māori. The net results are roughly halved: three years increase for Māori males and two years for Māori females.

Regardless of which of these simulations is accepted, it seems that Māori deaths might have been *over*-reported at that time, not *under*-reported; that is Pacific Island deaths were wrongly recorded as Māori. If these models have any validity, then a new set of questions must be raised. They would suggest that Māori life-expectation in the early 1990s was higher than at the end of the decade, even when official tables are accepted for the latter date. These results would reinforce the arguments we outline in the following paragraphs.

Thus we are forced back to a substantive postulate:

> That the deterioration in 1991-96, especially for Māori male cohorts, was a residual effect of a history of cycles of cohort gain and deterioration reinforced by period effects coming from restructuring.

We might adjust this slightly for females by postulating:

> That the negative effects of restructuring on Māori reinforced the residual cohort effects coming from a history of high fertility and its attendant physiological burdens.

Restructuring involved not just job loss, but also a shift in patterns of work through casualisation, contracting out and long hours often involving night shifts for women workers. Thus we would postulate:

> That casualisation etc fell disproportionately on Māori and Pacific Islanders, especially women in unskilled jobs such as office cleaning, and that, this would have reinforced residual cohort effects emanating from the physiological burdens of high levels of childbearing and pregnancy at young ages.

Finally, a detailed internationally peer-reviewed study of regional differences in hospitalisation and survivorship, using a new life-table technique[7] that analyses the prevalence and duration of hospitalisation for those still surviving, along with more conventional methods, is raising new questions about recent mortality trends. Specifically, initial results show that health restructuring in the 1990s seems to have had an effect on access to hospitalisation in some regions. This appears to have had more impact on Māori than on other population (Pool *et al.* forthcoming).

Towards a Conclusion

This paper has used a very robust well-established conventional technique, the life-table, employing it in a less familiar form, for generations or cohorts. The estimates come also from widely used robust demographic techniques developed since World War II, and based, in turn, on a significant body of bio-metric and actuarial theory.

The utility of the generation table approach is that, at least at a population level, it allows one to show how exposure to health risks in one period may produce residual effects that have negative health implications later in the life-spans of the cohorts one is observing. A key finding is that gains in survivorship have momentum effects that propel this advantage forward as these cohorts' survivors move up through the age-groups. That said, however, periods of gain may be followed later by cohort deterioration occurring among the same generations later in their life-cycle, and even by further cycles of reprise and deterioration. These cycles of gain, deterioration, reprise etc are more evident for males, and particularly for Māori.

This raises a major question for policy. Given that we have cohorts, particularly of Maori men, that have disproportionate levels of frailty, they may require extra measures of monitoring. For Māori women it is the history of reproduction that seems critical. Cohorts of both genders, however, may have seen their exposure to health risks in the past compounded by recent negative social and economic experiences that carry health risks (eg. the links between job-loss and uni-polar depression, seen in burden of disease exercises as a major cause of future problems). In this regard there seem few advocacy groups pushing for the monitoring of Māori middle aged men, yet they have the highest risks of premature mortality.

This is clear in the following tables for the cohorts born in the early 1940s. Not only have fewer Māori than Pakeha in any cohort reached 40 years but their health risks are much greater. The life-table data for the cohort of males born around 1940 show, for example, that fifteen per cent of all their deaths over the cohorts entire life span until now occurred at late middle-ages. This can be compared with the 11 per cent from the same cohort who died in infancy, or the 16 per cent who failed to survive to age five years, at a period in the past when death rates at young ages were still very high, but about to fall. In contrast, the high loss at late middle-ages comes at a period when only 1.4 per cent of the cohort born in the 1990s will have died at infancy, and only 1.7 per cent before five years.

Table 3: Numbers of survivors (l_x), by sex of a cohort of 100,000, born in the early 1940s, reaching 40 years, and 60 years, the probability of failing to survive through late middle-age ($_{20}q_{40}$), and the deaths ($_{20}d_{40}$) that will occur among them

	Māori		Non-Māori	
	Males	Females	Males	Females
l_{40}	75,781	80,168	92,199	94,858
l_{60}	60,581	68,015	87,662	91,633
$_{20}q_{40}$	0.201	0.152	0.049	0.034
$_{20}d_{40}$	15,200	12,153	4,537	3,195

Our concluding point relates to a different issue and is paraphrased from our 2002 paper to the Max Planck Institute. The cohort analysis provides a sobering thought for those researchers and policy analysts who see almost no limits to human longevity. There may be a risk of confounding short-term effects with longer term ones. The older cohorts of today in most developed countries (but not Pakeha New Zealand whose epidemiological transition, as we have seen, was earlier) benefited from improvements in cohort survivorship between 1900 and 1930. The momentum of this may still be being felt today when these cohorts are at early old age. But, if the Pakeha New Zealand experience were to apply, say to the Nordic countries or Western Europe, then these gains would be followed by smaller gains, or even by deterioration. Extending this logic, then Māori will be one further step behind.

Notes

This paper was first presented at the Workshop of the Seventh Annual Public Health Summer School, Wellington Clinical School of Medicine, University of Otago, 13th February 2003. Support for this research has come from an HRC grant on sub-national differentials in health. The present analysis has contributed to the theoretical framework essential to the empirical research there.

1 For Māori, we have drawn on Pool (1983, 1991 and 1994). These studies used a range of indirect estimation techniques employed widely in demography to estimate vital rates and construct life-tables where vital data are non-existent or of poor quality. See Appendices A and B.

2 George Stolnitz based his conclusion on the analysis of every available life-table, including historical ones. His work, building on the work of Jean Bourgeois-Pichat and the United Nations Population Division, plus theoretical work by Alfred Lotka, then fed into the development by Ansley Coale and Paul Demeny of model life-tables, auguably the most important development in 20th century demography.

3 In this section of the paper we also draw on recent official synthetic life-tables, see Appendix C.

4 There are also problems relating to the ages of persons in burial places, a common issue in paleo-demography. This technical issue is elaborated in Pool (1991:chapt 3), that was peer-reviewed prior to publication by Dr Janet Davidson, a leading NZ pre-historian.

5 Smallpox threatened only twice and this was much later, once when a ship with it on board was quarantined in Wellington harbour, and thus it was not introduced; and once in 1913 when it was quickly contained. In 1913, public health specialists, led by Sir Peter Buck (Te Rangihiroa) immediately addressed the epidemic. His paper on this (*Aust Med Congress, 10th Session*, Feb 1914:212-24) was probably New Zealand's first modern epidemiological study. In these days of threats of bio-terror, it is worth revisiting his paper as it has a "quasi-

experimental" design, comparing death rates for those innoculated by missionaries decades before with those not innoculated.

6 Recent detailed work using indirect estimation techniques by Portal Consulting (Tahu Kukutai, Ian Pool and Janet Sceats) for the Crown Forestry Rental Trust on the Central North Island provides interesting micro-level confirmation of this global finding. The rates estimated by indirect estimation could be confirmed, in one instance, by data coming from a totally independent source from health information collected by Sir Maui Pomare on the Rotorua district.

7 Developed at the Population Studies Centre; see Pool *et al.* (2000) and Cheung *et al.* (2001).

References

Ajwani, S., Blakely, T., Robson, B., Tobias, M. and Bonne M. (2003) *Decades of Disparity: Ethnic Mortality Trends in New Zealand 1980-1999*, Wellington: Ministry of Health and University of Otago.

Beaglehole, R (1977) *Coronary Heart Disease in New Zealand: An Epidemiological Study*, MD Thesis, University of Otago.

Buck, Sir P. (see Te Rangihiroa)

Cheung, J. (1999) *Mortality, Morbidity and Population Health Dynamics*, PhD Thesis, University of Waikato, Hamilton.

______ (2001) "The Long-term Trend of Non-Māori Mortality and its More Recent Compression Effect". Paper presented at the *Population Association of New Zealand Bi-Annual Conferenc*e, Hamilton.

Cheung, J., Katzenellenbogen, J., Baxendine, S., Pool, I. and Jackson, G. (2001) Hospital Utilisation Expectancies in New Zealand, 1980-98. *Australian Health Review* 24(4):46-56

Crosby, A. (1986) *Ecological Imperialism: The Biological Expansion of Europe, 900-1900*, Cambridge: Cambridge University Press.

Edson, N.L. (1943) "Tuberculosis in the Māori Race". *NZMJ* 42:102-110.

Hawke, G. (1985) *The Making of New Zealand*, Cambridge: Cambridge University Press.

Honey, J. (2001) "New Zealand Jobs, 1976-96: A Demographic Accounting". *Population Studies Centre, Discussion Paper No. 40*, Hamilton: University of Waikato.

Kannisto, V. (1994) "Development of Oldest-Old Mortality, 1950-1990: Evidence from 28 Developed Countries", *Odense Monographs on Population Aging 1*, Odense University Press.

MacLean, F. (1963) *The Challenge of Health*, Wellington: Govt Printer.

Oeppen, J. and Vaupel, J. (2002) "Broken Limits to life-Expectancy". *Science* 296:10029-31

Omran, A. (1982) "Epidemiologic Transition: Theory". In Ross, J. (ed. in chief) *International Encyclopaedia of Population*, v 1, New York: Free Press, 172-75

Pool, I. (1983) "Changing Patterns of Sex Differentials in Survival: An Examination of Data for Māori and Non-Māori …". In Lopez, A. and Ruzicka, L. (eds) *Sex Differentials in Mortality: Trends Determinants and Consequences*, Papers presented ANU/UN/WHO meeting Canberra 1981.

______ (1985) "Mortality Trends and Differentials". In ESCAP, Population Div. (eds) *The Population of New Zealand. Country Monograph Series*, v.1, New York and Bangkok: United Nations, 209-42.

______ (1991) *Te Iwi Māori*, Auckland: Auckland University Press.

______ (1994) "Cross-Comparative Perspectives in New Zealand Health". In Spicer, J., Trlin, A. and Walton, J. (eds) *Social Dimensions of Health and Disease*, Palmerston North: Dunmore.

______ (2002) "Transfers of Capital and Shifts in New Zealand's Regional Population Distribution 1840-1996". *Population Studies Centre Discussion Paper No. 42*, Hamilton: University of Waikato.

Pool, I. and Cheung, J. (2002) "Why were New Zealand Levels of Life-Expectation so High at the Dawn of the Twentieth Century?". *Population Studies Centre Discussion Paper No. 43*, Hamilton: University of Waikato.

Pool, I., Cheung, J., Baxendine, S. and Katzenellenbogen, J. (2000) "Hospitalisation Expectancies: An Innovative Extension of Health Expectancies". Report from *International Consultative Meeting on Health, Ageing and Development*, World Health Organization, Kobe, Japan, 1-3 September 1999.

Pool, I., Sceats, J., Baxendine, S., Cheung, J., Katzenellenbogen, J., and Dharmalingam, A. (forthcoming). S*ub-National Differentials in Health in New Zealand: Hospital Utilisation Expectancies and Other Population-Health Measures of Regional Trends.* Hamilton: University of Waikato.

Sceats, J. and Pool, I. (1985a) "Perinatal and Infant Mortality". In ESCAP, Population Div (eds), *The Population of New Zealand. Country Monograph Series*, v 1, New Yord and Bangkok: United Nations.

______ (1985b) "Fertility Regulation". In ESCAP, Population Division (eds) *The Population of New Zealand. Country Monograph Series*, v 1, New York and Bangkok: United Nations.

Stolnitz , G. (1955-56) "A Century of International Mortality Trends. Parts I and II". *Population Studies* 9 July, 1955, 10 July 1956: 24-55 and 17-42.

Te Rangihiroa (1914) "Smallpox among Māori in the Northern District*". Australian Medical Congress, 10th Session*, Feb: 212-24.

Turbott, H. (1935) *Tuberculosis in The East Coast Maori*, Wellington: Govt Printer.

Waldron, I. (1982) "An Analysis of the Causes of Sex Differences in Mortality and Morbidity". In Gove, W. and Carpenter, G. (eds) *The Fundamental Connection Between Nature and Nurture*, Lexington, Mass.: Lexington Books.

Appendix A: Non-Māori Cohort Life Tables

Probability of Surviving from Exact Ages x to x+n

Males

Exact age x	Birth Cohorts 1871-76	1876-81	1881-86	1886-91	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36	1936-41
0	0.88670	0.89356	0.89984	0.90233	0.90958	0.91535	0.91819	0.92731	0.93967	0.94603	0.95224	0.95997	0.96341	0.96497
1	0.94068	0.95699	0.96419	0.96747	0.97409	0.97216	0.97721	0.98087	0.97882	0.98028	0.98524	0.98813	0.98822	0.99026
5	0.97942	0.98340	0.98539	0.98968	0.98829	0.98875	0.99051	0.98775	0.98975	0.99200	0.99307	0.99332	0.99503	0.99503
10	0.98804	0.99019	0.99075	0.99145	0.99186	0.99192	0.99232	0.99238	0.99379	0.99474	0.99464	0.99490	0.99546	0.99661
15	0.98165	0.98472	0.98566	0.98746	0.98894	0.98807	0.98986	0.99075	0.99063	0.99094	0.99199	0.99281	0.99330	0.99414
20	0.97754	0.98065	0.98217	0.98515	0.97602	0.98459	0.98670	0.98735	0.98862	0.98609	0.98758	0.99175	0.99141	0.99340
25	0.97820	0.98128	0.98284	0.97911	0.98314	0.98549	0.98687	0.98837	0.98749	0.98895	0.99244	0.99281	0.99422	0.99323
30	0.97768	0.97904	0.97663	0.97930	0.98274	0.98568	0.98759	0.98710	0.98969	0.99116	0.99210	0.99315	0.99202	0.99330
35	0.97292	0.97162	0.97400	0.97825	0.98064	0.98234	0.98504	0.98794	0.98824	0.99017	0.99037	0.98959	0.99027	0.99105
40	0.96748	0.96830	0.97386	0.97499	0.97521	0.97844	0.98292	0.98431	0.98552	0.98515	0.98436	0.98465	0.98537	0.98722
45	0.95792	0.96152	0.96526	0.96697	0.96793	0.97168	0.97333	0.97576	0.97417	0.97234	0.97441	0.97413	0.97816	0.98092
50	0.94774	0.94953	0.95098	0.94746	0.95358	0.95535	0.95731	0.95742	0.95342	0.95588	0.95662	0.96373	0.96385	0.97202
55	0.92996	0.92717	0.92135	0.92830	0.92611	0.92934	0.92957	0.92299	0.92614	0.93018	0.93596	0.94184	0.95279	0.96182
60	0.88785	0.88381	0.88355	0.88786	0.88689	0.88544	0.88093	0.88101	0.88797	0.89611	0.90532	0.92195	0.93571	0.94885
65	0.82377	0.83039	0.82684	0.82689	0.82816	0.81941	0.81869	0.83000	0.83862	0.84859	0.87258	0.89197	0.90738	*0.91748*
70	0.73757	0.74828	0.74321	0.74333	0.72952	0.73568	0.73655	0.75924	0.76732	0.80236	0.82618	0.84748	*0.85963*	*0.87262*
75	0.63064	0.63108	0.62749	0.61699	0.61503	0.63100	0.64528	0.65780	0.69969	0.72975	0.76199	*0.77878*	*0.79359*	*0.80948*
80	0.49214	0.47893	0.47943	0.47407	0.49784	0.51053	0.52340	0.55785	0.59190	0.63855	*0.64438*	*0.66686*	*0.68406*	*0.69944*
85	0.30176	0.33287	0.31851	0.30447	0.35756	0.37633	0.42275	0.43557	0.45077	*0.48423*	*0.50212*	*0.51919*	*0.53433*	*0.54777*
90	0.19687	0.18256	0.16870	0.20274	0.23050	0.27319	0.26875	0.22872	*0.30331*	*0.32349*	*0.33679*	*0.35084*	*0.36154*	
95	0.05432	0.05285	0.09706	0.11664	0.13868	0.11291	*0.13588*	*0.14960*	*0.16134*	*0.17469*	*0.19109*	*0.20175*		
100		0.03670	0.04094	0.04913	0.02299	*0.03328*	*0.03693*	*0.04978*	*0.05121*	*0.05747*	*0.06551*			

Females

Exact age x	Birth Cohorts 1871-76	1876-81	1881-86	1886-91	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36	1936-41
0	0.90460	0.91094	0.91539	0.91789	0.92517	0.92925	0.93264	0.94174	0.95275	0.95785	0.96175	0.96813	0.97144	0.97296
1	0.94383	0.95899	0.96718	0.97277	0.97476	0.97362	0.97701	0.98201	0.98078	0.98178	0.98541	0.98942	0.99070	0.99155
5	0.98333	0.98677	0.98663	0.98958	0.99054	0.99134	0.99179	0.98972	0.99156	0.99321	0.99408	0.99452	0.99557	0.99651
10	0.98876	0.99042	0.99174	0.99106	0.99207	0.99439	0.99344	0.99408	0.99436	0.99671	0.99594	0.99687	0.99644	0.99847
15	0.98185	0.98435	0.98520	0.98691	0.98899	0.98996	0.98981	0.99217	0.99277	0.99401	0.99540	0.99585	0.99703	0.99775
20	0.97884	0.98158	0.98229	0.98526	0.98479	0.98488	0.98763	0.98948	0.99076	0.99202	0.99310	0.99632	0.99738	0.99770
25	0.97724	0.97814	0.98114	0.98046	0.98078	0.98635	0.98675	0.98892	0.99029	0.99180	0.99519	0.99672	0.99716	0.99697
30	0.97612	0.97816	0.97965	0.98000	0.98353	0.98393	0.98720	0.98890	0.99118	0.99390	0.99558	0.99561	0.99606	0.99583
35	0.97412	0.97724	0.97672	0.98163	0.98290	0.98520	0.98597	0.98762	0.99150	0.99249	0.99319	0.99392	0.99373	0.99410
40	0.97373	0.97308	0.97897	0.98048	0.97957	0.98266	0.98462	0.98733	0.98940	0.99012	0.98875	0.98944	0.98921	0.99107
45	0.96562	0.96791	0.96984	0.97234	0.97367	0.97350	0.97878	0.98273	0.98393	0.98244	0.98252	0.98344	0.98390	0.98683
50	0.95537	0.96056	0.96194	0.96277	0.96204	0.96748	0.97144	0.97525	0.97319	0.97426	0.97591	0.97782	0.97775	0.98103
55	0.94123	0.94385	0.94240	0.94439	0.95025	0.95803	0.96038	0.95931	0.96153	0.96278	0.96338	0.96591	0.97064	0.97634
60	0.91265	0.91105	0.92043	0.92343	0.93259	0.93593	0.93467	0.93905	0.94044	0.94589	0.94637	0.95530	0.96191	0.96606
65	0.85900	0.87412	0.88285	0.89015	0.89882	0.89712	0.90223	0.90961	0.90844	0.91716	0.92874	0.93775	0.94575	*0.95429*
70	0.79073	0.81028	0.82342	0.82833	0.83660	0.83985	0.84679	0.85992	0.86346	0.88299	0.89769	0.91239	*0.91947*	*0.92979*
75	0.69370	0.71199	0.71460	0.73539	0.73797	0.76166	0.77951	0.78110	0.81552	0.83168	0.85197	*0.85439*	*0.86931*	*0.87910*
80	0.56192	0.56187	0.58382	0.58917	0.62881	0.64715	0.66045	0.68951	0.71872	0.74603	*0.75980*	*0.76972*	*0.78266*	*0.79341*
85	0.38006	0.39374	0.39662	0.44557	0.48920	0.49048	0.53600	0.54851	0.57916	*0.60145*	*0.62003*	*0.63444*	*0.64692*	*0.65505*
90	0.23124	0.23080	0.24174	0.29267	0.29818	0.34312	0.34383	0.36667	*0.40187*	*0.42067*	*0.43392*	*0.44831*	*0.46534*	
95	0.07451	0.06458	0.14015	0.15210	0.18849	0.15591	*0.19504*	*0.21332*	*0.23244*	*0.25435*	*0.26923*	*0.27860*		
100	0.00352	0.04962	0.05058	0.07471	0.03407	*0.04919*	*0.05958*	*0.07073*	*0.08228*	*0.08927*	*0.09593*			

Probability of Surviving from Exact Ages x to x+n (continued)

Males

Birth Cohorts

Exact age x	1941-46	1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	0.96749	0.97176	0.97617	0.97792	0.97962	0.98189	0.98329	0.98550	0.98817	0.99063	0.99340	0.99440
1	0.99143	0.99465	0.99504	0.99568	0.99609	0.99623	0.99633	0.99691	0.99742	0.99781	0.99838	0.99863
5	0.99671	0.99743	0.99773	0.99780	0.99797	0.99782	0.99830	0.99856	0.99870	0.99903	0.99934	
10	0.99741	0.99763	0.99747	0.99791	0.99787	0.99839	0.99807	0.99830	0.99870	0.99863		
15	0.99486	0.99394	0.99293	0.99180	0.99368	0.99255	0.99381	0.99471	0.99570			
20	0.99243	0.99248	0.99092	0.99171	0.99114	0.99074	0.99271	0.99399				
25	0.99391	0.99358	0.99311	0.99243	0.99280	0.99359	0.99446					
30	0.99345	0.99349	0.99324	0.99332	0.99426	0.99384						
35	0.99179	0.99217	0.99182	0.99395	0.99388							
40	0.98875	0.99004	0.99181	0.99184								
45	0.98362	0.98696	0.98858									
50	0.97762	0.98157	*0.98338*									
55	0.96980	*0.97515*	*0.98015*									
60	*0.95798*	*0.96542*	*0.97120*									
65	*0.92911*	*0.93813*	*0.94596*									
70	*0.88026*	*0.88917*	*0.89675*									
75	*0.82104*	*0.82886*										
80	*0.70674*											
85												
90												
95												
100												

Females

Birth Cohorts

Exact age x	1941-46	1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	0.97522	0.97793	0.98139	0.98323	0.98482	0.98643	0.98749	0.98907	0.99052	0.99253	0.99469	0.99552
1	0.99294	0.99539	0.99564	0.99654	0.99675	0.99692	0.99703	0.99755	0.99793	0.99864	0.99872	0.99876
5	0.99784	0.99837	0.99825	0.99865	0.99835	0.99844	0.99889	0.99870	0.99897	0.99935	0.99923	
10	0.99815	0.99847	0.99862	0.99851	0.99840	0.99879	0.99882	0.99917	0.99899	0.99933		
15	0.99790	0.99784	0.99737	0.99717	0.99701	0.99739	0.99759	0.99760	0.99811			
20	0.99742	0.99730	0.99711	0.99668	0.99694	0.99736	0.99759	0.99836				
25	0.99717	0.99693	0.99711	0.99685	0.99752	0.99759	0.99774					
30	0.99598	0.99636	0.99643	0.99678	0.99721	0.99774						
35	0.99496	0.99489	0.99556	0.99645	0.99707							
40	0.99241	0.99263	0.99471	0.99508								
45	0.98809	0.99109	0.99181									
50	0.98513	0.98667	*0.99000*									
55	0.97912	*0.98591*	*0.98797*									
60	*0.97564*	*0.97819*	*0.98004*									
65	*0.96374*	*0.96702*	*0.96914*									
70	*0.93767*	*0.94244*	*0.94626*									
75	*0.88824*	*0.89331*										
80	*0.79849*											
85												
90												
95												
100												

Source: Computed and projected by Cheung (1999), based on published official statistics.
Note: Numbers in italics indicate projections.

Number of Survivors at Exact Age x

Males

Exact age x	Birth Cohorts 1871-76	1876-81	1881-86	1886-91	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36
0	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
1	88670	89356	89984	90233	90958	91535	91819	92731	93967	94603	95224	95997	96341
5	83409	85513	86761	87298	88601	88986	89727	90957	91977	92737	93818	94857	95206
10	81693	84094	85494	86397	87564	87986	88876	89843	91035	91995	93168	94223	94733
15	80716	83269	84703	85659	86851	87275	88193	89158	90470	91512	92668	93743	94303
20	79234	81996	83488	84584	85890	86234	87299	88334	89622	90683	91926	93068	93671
25	77455	80410	81999	83328	83830	84905	86138	87217	88602	89422	90784	92301	92867
30	75766	78905	80592	81587	82417	83673	85007	86202	87494	88434	90098	91637	92330
35	74075	77251	78709	79899	80995	82475	83952	85090	86592	87651	89386	91009	91593
40	72068	75058	76662	78161	79426	81018	82697	84064	85573	86790	88526	90061	90702
45	69725	72679	74658	76206	77457	79271	81284	82745	84334	85501	87141	88679	89375
50	66791	69882	72065	73689	74973	77026	79116	80739	82155	83136	84911	86385	87423
55	63300	66355	68532	69818	71492	73587	75738	77301	78328	79468	81227	83252	84263
60	58867	61522	63142	64812	66210	68388	70404	71348	72543	73919	76025	78410	80284
65	52265	54374	55789	57544	58721	60553	62022	62858	64416	66240	68827	72290	75123
70	43054	45152	46129	47582	48630	49618	50776	52172	54021	56210	60058	64480	68165
75	31756	33786	34283	35369	35477	36503	37399	39612	41451	45101	49619	54646	*58597*
80	20026	21322	21513	21823	21819	23033	24133	26057	29003	32912	37809	*42557*	*46502*
85	9856	10212	10314	10345	10862	11759	12631	14536	17167	21016	*24363*	*28380*	*31810*
90	2974	3399	3285	3150	3884	4425	5340	6331	7738	*10177*	*12233*	*14735*	*16997*
95	585	621	554	639	895	1209	1435	1448	*2347*	*3292*	*4120*	*5169*	*6145*
100	32	33	54	74	124	137	*195*	*217*	*379*	*575*	*787*	*1043*	
105		1	2	4	3	*5*	*7*	*11*	*19*	*33*	*52*		

Females

Exact age x	Birth Cohorts 1871-76	1876-81	1881-86	1886-91	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36
0	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
1	90460	91094	91539	91789	92517	92925	93264	94174	95275	95785	96175	96813	97144
5	85378	87358	88534	89289	90182	90474	91120	92480	93444	94040	94771	95789	96241
10	83955	86202	87350	88358	89329	89690	90372	91529	92655	93402	94210	95264	95814
15	83011	85376	86629	87568	88620	89187	89779	90987	92133	93094	93827	94966	95473
20	81504	84040	85347	86422	87645	88291	88865	90275	91466	92536	93395	94572	95189
25	79780	82492	83835	85148	86312	86956	87766	89325	90621	91798	92750	94223	94940
30	77964	80689	82254	83484	84653	85769	86603	88335	89741	91045	92305	93915	94670
35	76103	78926	80580	81814	83259	84390	85494	87354	88950	90489	91897	93502	94297
40	74133	77130	78704	80311	81835	83142	84295	86273	88194	89810	91271	92934	93706
45	72185	75053	77048	78743	80164	81700	82999	85179	87259	88922	90244	91952	92695
50	69704	72645	74725	76565	78053	79535	81237	83708	85857	87361	88667	90429	91203
55	66593	69780	71881	73715	75090	76948	78917	81636	83555	85113	86531	88424	89174
60	62679	65861	67740	69616	71355	73719	75790	78314	80340	81945	83361	85409	86556
65	57204	60003	62350	64285	66545	68995	70838	73541	75555	77511	78891	81591	83259
70	49138	52450	55046	57223	59812	61897	63913	66893	68637	71090	73269	76512	78742
75	38855	42499	45326	47400	50039	51984	54120	57523	59266	62772	65773	69809	*72401*
80	26954	30259	32390	34857	36927	39594	42187	44931	48332	52206	56036	*59644*	*62939*
85	15146	17002	18910	20537	23220	25624	27863	30981	34737	38947	*42577*	*45909*	*49260*
90	5756	6694	7500	9151	11359	12568	14934	16993	20118	*23425*	*26399*	*29127*	*31867*
95	1331	1545	1813	2678	3387	4312	5135	6231	*8085*	*9854*	*11455*	*13058*	*14829*
100	99	100	254	407	638	672	*1002*	*1329*	*1879*	*2506*	*3084*	*3638*	
105		5	13	30	22	*33*	*60*	*94*	*155*	*224*	*296*		

Number of Survivors at Exact Age x (continued)

Males

Birth Cohorts

Exact age x	1936-41	1941-46	1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
1	96467	96749	97176	97617	97792	97962	98189	98329	98550	98817	99063	99340	99440
5	95557	95920	96656	97133	97369	97579	97818	97968	98245	98562	98846	99179	99304
10	95.82	95604	96408	96912	97155	97381	97605	97802	98104	98433	98751	99113	
15	94759	95357	96180	96667	96952	97173	97448	97613	97937	98305	98616		
20	94204	94867	95597	95983	96157	96559	96723	97009	97419	97883			
25	93582	94149	94878	95112	95360	95704	95827	96302	96833				
30	92949	93576	94269	94456	94638	95015	95212	95769					
35	92326	92962	93655	93818	94006	94470	94625						
40	91500	92199	92922	93050	93436	93892							
45	90331	91162	91997	92288	92674								
50	88607	89669	90797	91234									
55	86128	87662	89123	*89718*									
60	82840	85015	*86909*	*87937*									
65	78602	*81443*	*83903*	*85404*									
70	*72116*	*75669*	*78712*	*80789*									
75	*62930*	*66608*	*69989*	*72448*									
80	*50940*	*54688*	*58011*										
85	*35630*	*38650*											
90	*19517*												
95													
100													
105													

Females

Birth Cohorts

xact age x		1941-46	1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
1	97296	97522	97793	98139	98323	98482	98643	98749	98907	99052	99253	99469	99552
5	96474	96834	97342	97711	97983	98162	98339	98456	98664	98847	99118	99342	99429
10	96137	96624	97184	97540	97851	98000	98185	98346	98536	98745	99053	99265	
15	95990	96445	97035	97405	97705	97844	98067	98229	98454	98646	98987		
20	95775	96243	96825	97149	97429	97551	97811	97992	98218	98459			
25	95555	95995	96564	96869	97106	97252	97553	97756	98057				
30	95265	95723	96268	96589	96800	97011	97318	97535					
35	94867	95338	95918	96244	96488	96740	97098						
40	94308	94858	95428	95817	96145	96456							
45	93466	94138	94725	95310	95672								
50	92235	93017	93880	94530									
55	90485	91633	92629	*93585*									
60	88344	89720	*91324*	*92459*									
65	85346	*87534*	*89332*	*90613*									
70	*81444*	*84360*	*86386*	*87817*									
75	*75726*	*79102*	*81414*	*83098*									
80	*66571*	*70262*	*72728*										
85	*52819*	*56103*											
90	*34599*												
95													
100													
105													

Source: Computed and projected by Cheung (1999), based on published official statistics.
Note: Numbers in italics indicate projections.

Appendix B. Māori Cohort Life Tables

Probability of Surviving from Exact Ages x to x+n

Males

Exact age x	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36	1936-41	1941-46
	Birth Cohorts										
0	0.62913	0.62913	0.73413	0.73413	0.75667	0.77801	0.79826	0.88100	0.88100	0.88100	0.89350
1	0.84513	0.87171	0.89828	0.90353	0.91361	0.92293	0.93321	0.93575	0.92925	0.92925	0.93575
5	0.96253	0.96937	0.97079	0.97352	0.97608	0.97266	0.96900	0.97100	0.97300	0.97500	0.98269
10	0.96955	0.97339	0.97598	0.97592	0.97355	0.97200	0.97600	0.97850	0.97950	0.98576	0.99208
15	0.95918	0.96272	0.96604	0.95632	0.96000	0.97000	0.96425	0.96275	0.97192	0.98448	0.98830
20	0.95387	0.95804	0.95803	0.95725	0.95975	0.95800	0.95250	0.96210	0.97905	0.98450	0.98595
25	0.95270	0.95151	0.95200	0.96000	0.96275	0.96025	0.96610	0.97641	0.98044	0.98478	0.98698
30	0.95179	0.95650	0.95750	0.96075	0.96625	0.96876	0.97151	0.97609	0.98020	0.98213	0.98480
35	0.95275	0.95025	0.95075	0.95425	0.95833	0.96572	0.97101	0.97299	0.97362	0.97590	0.98162
40	0.93875	0.94150	0.94450	0.95035	0.95980	0.98063	0.98098	0.96241	0.96163	0.96860	0.97562
45	0.92925	0.93375	0.93685	0.94065	0.93940	0.94344	0.94448	0.94020	0.94999	0.96017	0.96492
50	0.90325	0.90547	0.90494	0.91057	0.91726	0.91355	0.90917	0.92131	0.93560	0.94473	0.94262
55	0.85766	0.86683	0.87844	0.87315	0.85620	0.86318	0.88137	0.89782	0.91092	0.90502	0.90088
60	0.79405	0.79587	0.79483	0.79126	0.80465	0.82579	0.84470	0.85961	0.85506	0.85864	
65	0.72366	0.73498	0.74101	0.73362	0.74856	0.77878	0.79814	0.79410	0.79588		
70	0.67321	0.67014	0.67432	0.68110	0.70191	0.72762	0.72308	0.71758			
75	0.68952	0.71607	0.58435	0.60964	0.63343	0.63822	0.62719				
80	0.44799	0.46708	0.48374	0.50326	0.51700	0.49475					
85	0.32776	0.32483	0.36512	0.35225	0.37882						
90	0.17829	0.22041	0.17901	0.14562							
95	0.10499	0.07053									
100											

Females

Exact age x	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36	1936-41	1941-46
	Birth Cohorts										
0	0.60627	0.60627	0.71731	0.71731	0.74070	0.76273	0.78353	0.88800	0.90100	0.91400	0.91700
1	0.81044	0.84300	0.87556	0.88181	0.89378	0.90478	0.91902	0.92850	0.92950	0.93325	0.94175
5	0.94990	0.95927	0.96115	0.96479	0.96819	0.96741	0.96775	0.97325	0.97600	0.97600	0.98392
10	0.95896	0.96082	0.96441	0.96776	0.96519	0.96200	0.96400	0.96800	0.97150	0.98065	0.99038
15	0.94995	0.95442	0.95859	0.94980	0.94200	0.94800	0.95400	0.96000	0.97377	0.98724	0.99150
20	0.94613	0.95098	0.94666	0.94150	0.94450	0.94700	0.94900	0.96400	0.98273	0.98926	0.99263
25	0.94477	0.94419	0.94425	0.94975	0.95150	0.95050	0.96303	0.98104	0.98777	0.99005	0.99142
30	0.94561	0.94725	0.94175	0.94375	0.95325	0.96666	0.97892	0.98350	0.98641	0.98851	0.99007
35	0.92625	0.92475	0.92825	0.93675	0.95241	0.96850	0.97222	0.97664	0.98020	0.98129	0.98612
40	0.92125	0.92325	0.93175	0.94173	0.95112	0.95595	0.96477	0.96975	0.97080	0.97712	0.98247
45	0.89775	0.90725	0.91765	0.92487	0.93407	0.94568	0.95306	0.95597	0.96073	0.96960	0.97383
50	0.87775	0.88348	0.89792	0.89965	0.90614	0.91781	0.92674	0.93536	0.95165	0.95777	0.95487
55	0.86335	0.86039	0.85748	0.86271	0.87798	0.89167	0.90912	0.92450	0.93120	0.92887	0.92866
60	0.80645	0.80619	0.82572	0.83278	0.84350	0.86824	0.88529	0.89793	0.89387	0.88858	
65	0.75654	0.78034	0.78159	0.78995	0.80997	0.83725	0.85794	0.84899	0.83725		
70	0.71436	0.71997	0.73119	0.75547	0.78319	0.80526	0.79333	0.78671			
75	0.63310	0.66793	0.70046	0.71790	0.73526	0.72507	0.71324				
80	0.55971	0.60451	0.60866	0.62266	0.62567	0.60511					
85	0.41699	0.43635	0.46732	0.47720	0.44741						
90	0.25013	0.28383	0.27693	0.25863							
95	0.14073	0.12122									
100	0.03613										

Probability of Surviving from Exact Ages x to x+n (continued)

Males

Exact age x	Birth Cohorts 1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	0.90600	0.92024	0.93307	0.94988	0.96650	0.97498	0.98025	0.98168	0.98400	0.98594	0.98868
1	0.95464	0.97500	0.98239	0.98768	0.99101	0.99351	0.99579	0.99665	0.99700	0.99719	0.99749
5	0.98910	0.99122	0.99443	0.99552	0.99619	0.99726	0.99815	0.99841	0.99854	0.99875	
10	0.99341	0.99511	0.99591	0.99657	0.99761	0.99768	0.99774	0.99791	0.99825		
15	0.98957	0.98940	0.99032	0.99174	0.99212	0.99268	0.99302	0.99329			
20	0.98582	0.98577	0.98764	0.98956	0.99004	0.98928	0.99020				
25	0.98646	0.98818	0.99041	0.99094	0.98881	0.98837					
30	0.98816	0.98972	0.99132	0.98954	0.98766						
35	0.98562	0.98733	0.98744	0.98802							
40	0.97794	0.97999	0.98091								
45	0.96615	0.96692									
50	0.94297										
55											
60											
65											
70											
75											
80											
85											
90											
95											
100											

Females

Exact age x	Birth Cohorts 1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	0.92000	0.92960	0.94909	0.96114	0.97531	0.97547	0.98529	0.98278	0.98655	0.99080	0.98975
1	0.96062	0.97800	0.98564	0.99057	0.99275	0.99441	0.99598	0.99739	0.99795	0.99804	0.99817
5	0.99294	0.99500	0.99678	0.99769	0.99787	0.99825	0.99849	0.99861	0.99886	0.99874	
10	0.99380	0.99659	0.99736	0.99790	0.99822	0.99846	0.99881	0.99870	0.99862		
15	0.99432	0.99477	0.99442	0.99561	0.99674	0.99719	0.99658	0.99666			
20	0.99401	0.99406	0.99502	0.99622	0.99682	0.99617	0.99628				
25	0.99345	0.99480	0.99563	0.99643	0.99606	0.99575					
30	0.99176	0.99348	0.99465	0.99443	0.99440						
35	0.98970	0.99173	0.99174	0.99164							
40	0.98562	0.98566	0.98586								
45	0.97347	0.97542									
50	0.95647										
55											
60											
65											
70											
75											
80											
85											
90											
95											
100											

Source: Computed by Pool (1983). Pool employed a mix of indirect estimation techniques to identify the model life tables for the period up to 1921, adjustments to the official data using indirect estimation techniques for the period 1926 to 1941, direct computation with adjustments to overcome problems in the vital data for 1946, official tables from 1951 to 1996, and direct computation for 2001.

Note: Cells shaded in gray indicate calculations adversely affected by changes in ethnicity coding introduced in the late 1990s (see text).

Number of Survivors at Exact Age x

Males

Exact age x	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36	1936-41
	Birth Cohorts									
0	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
1	62,913	62,913	73,413	73,413	75,667	77,801	79,826	88,100	88,100	88,100
5	53,170	54,842	65,945	66,331	69,130	71,805	74,494	82,440	81,867	81,867
10	51,177	53,162	64,019	64,574	67,477	69,842	72,185	80,049	79,657	79,820
15	49,619	51,747	62,481	63,019	65,692	67,886	70,453	78,328	78,024	78,684
20	47,594	49,818	60,360	60,267	63,064	65,850	67,934	75,410	75,833	77,462
25	45,398	47,728	57,826	57,690	60,526	63,084	64,707	72,552	74,244	76,262
30	43,251	45,414	55,051	55,383	58,271	60,576	62,514	70,841	72,792	75,101
35	41,166	43,438	52,711	53,209	56,305	58,684	60,733	69,147	71,350	73,759
40	39,221	41,277	50,115	50,775	53,958	56,672	58,972	67,279	69,468	71,981
45	36,818	38,862	47,334	48,254	51,789	55,574	57,850	64,750	66,803	69,721
50	34,213	36,288	44,344	45,390	48,651	52,431	54,638	60,878	63,462	66,944
55	30,903	32,857	40,129	41,331	44,625	47,899	49,676	56,088	59,375	63,244
60	26,504	28,482	35,251	36,088	38,208	41,345	43,783	50,356	54,086	57,237
65	21,046	22,668	28,019	28,555	30,744	34,142	36,983	43,287	46,247	49,146
70	15,230	16,660	20,762	20,948	23,014	26,590	29,518	34,374	36,807	
75	10,253	11,165	14,000	14,268	16,154	19,347	21,344	24,666		
80	7,070	7,995	8,181	8,698	10,232	12,348	13,387			
85	3,167	3,734	3,958	4,378	5,290	6,109				
90	1,038	1,213	1,445	1,542	2,004					
95	185	267	259	225						
100	19	19								

Females

Exact age x	1891-96	1896-01	1901-06	1906-11	1911-16	1916-21	1921-26	1926-31	1931-36	1936-41
	Birth Cohorts									
0	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
1	60,627	60,627	71,731	71,731	74,070	76,273	78,353	88,800	90,100	91,400
5	49,135	51,109	62,805	63,253	66,202	69,010	72,008	82,451	83,748	85,299
10	46,673	49,027	60,365	61,026	64,096	66,761	69,686	80,245	81,738	83,252
15	44,757	47,106	58,216	59,058	61,865	64,224	67,177	77,677	79,408	81,641
20	42,517	44,959	55,806	56,094	58,277	60,885	64,087	74,570	77,326	80,599
25	40,227	42,755	52,829	52,812	55,043	57,658	60,818	71,886	75,990	79,734
30	38,005	40,369	49,884	50,158	52,373	54,804	58,570	70,523	75,061	78,940
35	35,938	38,239	46,978	47,337	49,925	52,977	57,335	69,359	74,041	78,033
40	33,288	35,362	43,607	44,343	47,549	51,308	55,743	67,739	72,575	76,573
45	30,666	32,648	40,631	41,759	45,225	49,048	53,779	65,690	70,456	74,821
50	27,531	29,620	37,285	38,622	42,243	46,383	51,254	62,798	67,689	72,546
55	24,165	26,169	33,479	34,746	38,278	42,571	47,499	58,739	64,416	69,482
60	20,863	22,515	28,708	29,976	33,607	37,959	43,183	54,304	59,984	64,540
65	16,825	18,151	23,705	24,963	28,348	32,958	38,229	48,761	53,618	57,349
70	12,729	14,164	18,527	19,720	22,961	27,594	32,799	41,398	44,891	
75	9,093	10,198	13,547	14,898	17,983	22,220	26,020	32,568		
80	5,757	6,811	9,489	10,695	13,222	16,111	18,559			
85	3,222	4,118	5,776	6,659	8,273	9,749				
90	1,344	1,797	2,699	3,178	3,701					
95	336	510	747	822						
100	47	62								

Number of Survivors at Exact Age x (continued)

Males

	Birth Cohorts											
Exact age x	1941-46	1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
1	89,350	90,600	92,024	93,307	94,988	96,650	97,498	98,025	98,168	98,400	98,594	98,868
5	83,609	86,490	89,723	91,664	93,818	95,781	96,865	97,612	97,839	98,105	98,317	98,620
10	82,162	85,548	88,936	91,153	93,397	95,416	96,600	97,431	97,683	97,962	98,194	
15	81,511	84,984	88,501	90,780	93,077	95,188	96,376	97,211	97,480	97,790		
20	80,558	84,097	87,563	89,902	92,309	94,437	95,670	96,533	96,826			
25	79,426	82,905	86,317	88,790	91,345	93,497	94,644	95,587				
30	78,392	81,782	85,296	87,938	90,517	92,450	93,544					
35	77,200	80,814	84,419	87,175	89,570	91,309						
40	75,781	79,652	83,350	86,081	88,497							
45	73,934	77,895	81,682	84,438								
50	71,340	75,258	78,980									
55	67,247	70,966										
60	60,581											
65												
70												
75												
80												
85												
90												
95												
100												

Females

	Birth Cohorts											
Exact age x	1941-46	1946-51	1951-56	1956-61	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91	1991-96	1996-01
0	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
1	91,700	92,000	92,960	94,909	96,114	97,531	97,547	98,529	98,278	98,655	99,080	98,975
5	86,358	88,377	90,915	93,546	95,208	96,824	97,002	98,133	98,021	98,453	98,886	98,794
10	84,970	87,753	90,460	93,245	94,988	96,618	96,832	97,985	97,885	98,340	98,761	
15	84,152	87,209	90,152	92,999	94,788	96,445	96,683	97,868	97,758	98,205		
20	83,437	86,714	89,680	92,480	94,372	96,131	96,412	97,533	97,431			
25	82,822	86,194	89,148	92,020	94,015	95,824	96,043	97,171				
30	82,112	85,630	88,684	91,617	93,679	95,446	95,634					
35	81,296	84,924	88,106	91,127	93,157	94,912						
40	80,168	84,049	87,377	90,374	92,379							
45	78,762	82,810	86,124	89,096								
50	76,701	80,613	84,007									
55	73,239	77,104										
60	68,015											
65												
70												
75												
80												
85												
90												
95												
100												

Source: Computed by Pool (1983). Pool employed a mix of indirect estimation techniques to identify the model life tables for the period up to 1921, adjustments to the official data using indirect estimation techniques for the period 1926 to 1941, direct computation with adjustments to overcome problems in the vital data for 1946, official tables from 1951 to 1996, and direct computation for 2001.

Note: Cells shaded in gray indicate calculations adversely affected by changes in ethnicity coding introduced in the late 1990s (see text).

Appendix C: Synthetic Life Tables

2001

Māori Males

Exact age x	l_x	p_x	L_x	T_x	e_x
0	100,000	0.99176	99,300	6,831,583	68.32
1	99,176	0.99760	396,229	6,732,283	67.88
5	98,938	0.99890	494,419	6,336,054	64.04
10	98,830	0.99867	493,818	5,841,636	59.11
15	98,698	0.99364	491,918	5,347,818	54.18
20	98,069	0.99133	488,222	4,855,900	49.51
25	97,219	0.98929	483,494	4,367,677	44.93
30	96,178	0.98771	477,936	3,884,183	40.39
35	94,996	0.98851	472,253	3,406,248	35.86
40	93,905	0.97970	464,760	2,933,995	31.24
45	91,999	0.96792	452,615	2,469,236	26.84
50	89,047	0.94703	433,444	2,016,620	22.65
55	84,330	0.90293	401,188	1,583,177	18.77
60	76,145	0.86961	355,902	1,181,989	15.52
65	66,216	0.80547	298,877	826,087	12.48
70	53,335	0.71893	229,197	527,210	9.88
75	38,344	0.61827	155,127	298,013	7.77
80	23,707	0.46708	86,949	142,887	6.03
85	11,073	0.43907	39,837	55,937	5.05
90	4,862	0.18033	14,346	16,100	3.31
95	877		1,753	1,753	2.00

Māori Females

Exact age x	l_x	p_x	L_x	T_x	e_x
0	100,000	0.99267	99,377	7,239,334	72.39
1	99,267	0.99839	396,750	7,139,957	71.93
5	99,108	0.99851	495,171	6,743,207	68.04
10	98,960	0.99887	494,523	6,248,036	63.14
15	98,849	0.99739	493,598	5,753,513	58.21
20	98,591	0.99716	492,254	5,259,915	53.35
25	98,311	0.99596	490,560	4,767,661	48.50
30	97,913	0.99432	488,175	4,277,101	43.68
35	97,357	0.99193	484,819	3,788,927	38.92
40	96,571	0.98671	479,646	3,304,107	34.21
45	95,287	0.97734	471,039	2,824,461	29.64
50	93,128	0.95842	455,960	2,353,422	25.27
55	89,256	0.93131	430,950	1,897,462	21.26
60	83,124	0.88983	392,728	1,466,511	17.64
65	73,967	0.83603	339,512	1,073,784	14.52
70	61,838	0.79334	277,242	734,272	11.87
75	49,059	0.71405	210,222	457,029	9.32
80	35,030	0.58678	138,963	246,807	7.05
85	20,555	0.43072	73,521	107,844	5.25
90	8,853	0.27536	28,228	34,323	3.88
95	2,438		6,095	6,095	2.50

2001

Non-Māori Males

Exact age x	l_x	p_x	L_x	T_x	e_x
0	100,000	0.99442	99,526	7,680,944	76.81
1	99,442	0.99863	397,496	7,581,418	76.24
5	99,306	0.99934	496,366	7,183,922	72.34
10	99,240	0.99863	495,862	6,687,556	67.39
15	99,104	0.99570	494,457	6,191,694	62.48
20	98,679	0.99399	491,910	5,697,237	57.74
25	98,085	0.99446	489,068	5,205,327	53.07
30	97,542	0.99384	486,206	4,716,259	48.35
35	96,941	0.99388	483,221	4,230,052	43.64
40	96,348	0.99184	479,774	3,746,832	38.89
45	95,562	0.98858	475,080	3,267,058	34.19
50	94,470	0.98157	467,998	2,791,977	29.55
55	92,729	0.96980	456,643	2,323,980	25.06
60	89,928	0.94885	438,143	1,867,337	20.76
65	85,329	0.90738	406,885	1,429,194	16.75
70	77,425	0.84748	357,605	1,022,309	13.20
75	65,617	0.76199	289,040	664,704	10.13
80	49,999	0.63855	204,816	375,664	7.51
85	31,927	0.45077	115,797	170,848	5.35
90	14,392	0.22872	44,209	55,051	3.83
95	3,292		10,842	10,842	3.29

Non-Māori Females

Exact age x	l_x	p_x	L_x	T_x	e_x
0	100,000	0.99582	99,645	8,184,966	81.85
1	99,582	0.99876	398,083	8,085,321	81.19
5	99,459	0.99923	497,104	7,687,238	77.29
10	99,382	0.99933	496,745	7,190,134	72.35
15	99,315	0.99811	496,107	6,693,390	67.40
20	99,127	0.99836	495,230	6,197,283	62.52
25	98,965	0.99774	494,265	5,702,053	57.62
30	98,741	0.99774	493,149	5,207,788	52.74
35	98,518	0.99707	491,868	4,714,640	47.86
40	98,229	0.99508	489,937	4,222,771	42.99
45	97,746	0.99181	486,729	3,732,834	38.19
50	96,946	0.98667	481,499	3,246,105	33.48
55	95,654	0.97912	473,276	2,764,607	28.90
60	93,656	0.96606	460,335	2,291,331	24.47
65	90,478	0.94575	440,117	1,830,996	20.24
70	85,569	0.91239	409,104	1,390,879	16.25
75	78,073	0.85197	361,469	981,774	12.58
80	66,515	0.74603	290,343	620,305	9.33
85	49,622	0.57916	195,903	329,962	6.65
90	28,739	0.36667	98,192	134,058	4.66
95	10,538		35,866	35,866	3.40

Source: Estimated by the authors based on the 2001 Census population and vital data.

Appendix D

Non-Māori tables were constructed either by Jit Cheung or were drawn from official sources. The recent tables for 2001 were computed by Jit Cheung since the official life tables were not available at the time of the preparation of this paper. There is a small difference to official tables.

Enumerations of Non-Māori population and deaths have been relatively reliable since the late 19th century. Historical Non-Māori mortality data are considered of very high quality by international standard (Kannisto 1994)

Māori tables were constructed either by Ian Pool or were drawn from official sources. The tables for year prior to 1945 were constructed using the Coale-Demeny indirect estimation techniques. The rationale and methods were discussed in Pool (1964, 1977, 1991).

Māori data suffer from reporting problems. For historical periods these are covered in Pool (1964, 1977, 1991).

The text covers some data issues over recent periods. We have chosen here to use official tables. Ajwani *et al.* (2003) have recently reworked Māori tables to allow for estimated under-reporting. In the text we suggest another scenario. Neither re-computation would change our basic argument.

That said, a detailed regional study being edited at present (Pool *et al.* forthcoming) has raised another set of issues relating to regional differences in reporting not just of deaths but also of hospitalisation data. An analysis being completed at present reviews these differences, the results of which will throw further light on national trends.