Assessing Infant Mortality in Prehistoric New Zealand: a Life Table Approach

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ABSTRACT

Previous estimates of longevity in prehistoric New Zealand have not attempted to gauge the effects of infant under-representation in skeletal samples. As life expectancy at birth is derived from infant mortality rates, calculations of average age at death for prehistoric New Zealand represent adult mortality only.

A life table was calculated for prehistoric New Zealand from available skeletal reports and then recalculated to take into consideration infant under-representation in the samples. This gives a realistic estimate of life expectancy at birth. Given the higher inferred infant mortality rates of between 150 and 300 per thousand, life expectancy at birth in prehistoric New Zealand would have been between 19 and 24 years.

Keywords: NEW ZEALAND, PREHISTORIC, LIFE TABLES, LIFE EXPECTANCY, INFANT MORTALITY, PALEODEMOGRAPHY, TAPHONOMY.

INTRODUCTION

Previous estimates of length of life of prehistoric New Zealanders have dealt mainly with those individuals over the age of fifteen at death, ignoring to a large degree the effects of infant mortality on calculations.

The most widely cited estimate of average age at death is 31 or 32 years in late prehistoric times for the whole country (Houghton 1980: 97). This was derived from a sample of 32 individuals. Two other estimates of average age at death have been made for the prehistoric population of New Zealand as a whole. An average age at death of 28.8 ($\pm$6 years) for males and 30.4 ($\pm$6 years) for females was calculated by Simpson (1979: 136) from a sample of 182 adult and infant femora. A higher estimate of average age at death of 37 years was made by Phillips (1980: 164) from a sample of 33 adult female individuals.

Provenanced samples have also yielded cemetery-specific estimates of average age at death. The Palliser Bay population of 16 individuals was studied by Sutton (1974, 1979). He calculated an average age at death of 38.13 years for adults, of 2.78 years for subadults and 20.45 years for the total population. This population appears to represent only the very young and the very old, as there are no young adults (Sutton 1974: 143). The Wairau Bar population showed an average age at death for adult males of 28 and for adult females of 29 from a sample of 40 individuals (Houghton 1975). This cemetery has provided the largest provenanced sample examined from prehistoric New Zealand.

These estimates, which are based on the calculation of average age at death, are an indication only of life expectancy in adulthood. This is because the samples used do not include representative infant and child numbers, which are under-enumerated in the available skeletal series.

Infant under-representation is a frequent problem with skeletal populations (Buikstra and Konigsberg 1985: 402; Peterson 1975: 233; Moore *et al.* 1975: 57). This anomalous postmortem representation results from natural taphonomic processes (adult remains are usually better preserved), age differentiated burial practices, or biased excavation and recovery procedures.

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As infant and child mortality rates increase, there is a corresponding decrease in life expectancy at birth. Thus if the level of infant mortality represented in the skeletal series is too low, calculations of life expectancy at birth will be too high. The estimation of an accurate infant mortality rate and life expectancy at birth is not then possible from these calculations.

The common statistical tool for calculations of life expectancy and mortality rates for all age groups of a population is the life table. Sutton (1986: 319) and Houghton (1980: 98) argue that it is unrealistic to develop a life table for prehistoric New Zealand because of inadequate representation of those under 15 years of age. However, as age specific mortality and life expectancy at birth calculated in life tables are unaffected by the degree of infant under-representation (Moore *et al.* 1975: 60; Swedlund and Armelagos 1976: Table 4:4), it is plausible to develop a life table from the available data and to infer the appropriate infant representation.

This paper attempts the assessment of an appropriate level of infant mortality in prehistoric New Zealand, and considers the ways in which such an assessment would affect calculations of expected length of life.

METHODS AND MATERIALS

Life tables based on archaeologically derived data have limitations that need to be considered if appropriate conclusions are to be drawn from them. The sample used is assumed to represent the entire population and to be stable; that is, without the effects of erratic growth, decline or migration. The study population is also assumed to be free from errors in age and sex estimates. It is unlikely these conditions will be met in practice because of the inherent nature of archaeologically derived samples. This is especially true for prehistoric New Zealand where skeletal material is infrequent and cemetery size is generally small (Sutton 1977: 177).

Despite the problems associated with sampling and age determination, life tables are an extremely useful and informative means by which to investigate certain aspects of prehistoric mortality (Acsadi and Nemeskeri 1970: 72; Moore *et al.* 1975: 51). This is because they make the very best possible use of a limited and biased data base. Life table modelling for prehistoric New Zealand is not valid in itself, because of the effects of a limited and probably biased sample, yet life tables can be used to examine certain aspects of the overall mortality, and in particular for the reconstruction of expected levels of infant mortality.

A life table for prehistoric New Zealand was calculated from a sample of 172 individuals collated from all available skeletal reports (Table 1; see Appendix for sources). The columns on a life table correspond to various estimated population parameters (see key). For a fuller explanation of life table construction for prehistoric populations see Acsadi and Nemeskeri (1970), Hassan (1981), Weiss (1973) and Hall (1978).

The sample size of 172, small by paleodemographic standards, is not site-specific and covers a wide geographic and temporal range. One consequence of small sample size is the magnification of errors introduced when determining the age of individuals. The problem of correct aging is especially difficult in older age groups when ossification is complete and subsequent age related changes are osteologically ambiguous or subtle (Stewart 1955: 198). Few skeletons from prehistoric New Zealand have been assigned ages over 50 years. This absence of elderly skeletons could be a reflection of the problems of age assessment beyond middle adulthood. The effect of aging discrepancies on paleodemographic analysis may be overcome by using five year age intervals in the life table. Fortunately, aging of older individuals to narrow limits is not crucial to the reconstruction of infant mortality rates. Identification of young age classes is highly accurate. Low levels of infant representation are not therefore due to incorrect estimates of age at death.

Certain patterns of infant and child mortality appear universal in small scale and prehistoric populations (Weiss 1973: 26) and are expected to have occurred in prehistoric New Zealand. The interval from birth to one year (the infant period) has the highest variability in mortality, yet always displays a high mortality rate. This mortality rate decreases slowly but remains high from one to five years of age. Mortality continues to decrease steadily until age 10. The period of adolescence (10–15) has the lowest mortality rate of all age intervals. In a representative sample one would expect age specific mortality at birth to be higher than at ages 10 to 20. Weiss (1973) proposes that prehistoric mortality should fall between 30 and 70 percent in the interval from birth to 15 years of life, and between 10 and 40 percent in the first year of life. It is this mortality pattern that gives the "U" shaped mortality curve characteristic of small scale societies.

The unrevised overall New Zealand lifetable has a mortality rate of 18.02 percent by 15 years and a mortality under one year of age of 3.5 percent. Age specific mortality at birth is lower than in the period of childhood (one to five years). This infant mortality rate of 35 per thousand is surprisingly low. It is improbable that infant mortality was as low as indicated by the skeletal sample used to construct the life table. The corresponding life expectancy at birth of around 27 years is therefore too high.

The healthiest and most "successful" prehistoric and small scale populations display an infant mortality rate of about 100 per thousand (Weiss 1973: 27). Isolated observations show both fatal and debilitating diseases to have been present in New Zealand during the prehistoric period, but there is little evidence that the prehistoric Maori were an exceptionally unhealthy or stressed people (Houghton 1980: 147). A more realistic lower limit for infant mortality in prehistoric New Zealand can therefore be set at around 150 per thousand (q_o of 0.15).

It is plausible to argue that infant mortality during the prehistoric period was lower than during the historic period when the introduction of acute infectious diseases caused a dramatically high infant mortality rate. Before European arrival, acute infectious diseases were unknown in New Zealand (Houghton 1980: 131). By 1850, when acute infectious diseases were exerting a strong influence on the Maori population, Maori infant mortality has been estimated to have been between 365 and 419 per thousand (Pool 1977: Table 5.5). In view of this, we can assume a maximum infant mortality rate for prehistoric New Zealand of around 300 per thousand (q_o of 0.30).

A FORTRAN IV computer programme was used to construct several life tables that systematically varied infant mortality rates for prehistoric New Zealand. Life tables with arbitrary infant mortality rates of 15, 20, 25 and 30 percent, or as close to these figures as a limited sample size would allow (actually 153, 198, 249 and 297 per thousand) are presented in Tables 2, 3, 4 and 5 respectively. Thus, infant mortality was varied between the minimum and maximum feasible rates (150 to 300 per thousand).

DISCUSSION

The recalculation of the life table to include expected infant mortality levels produces a mortality structure more similar to the "U" shaped model table profiles that are characteristic of "anthropological" populations (such as those described by Weiss 1973). This strongly suggests that the altered life table represents prehistoric Maori mortality more accurately than the unadjusted life table.

Pool (pers. comm., quoted by Sutton 1986: 319) has argued that the life table for the New Zealand Maori twenty years after Captain Cook's arrival would most closely have resembled the Coale and Demeny (1966) West 7 model, which has a life expectancy at birth of 35 and an infant mortality rate of 214 per thousand. Sutton (1986: 319) posits that this is highly unlikely. Sutton's argument (ibid.) is based on estimations of life expectancy at age 15, (which can be inferred from adult skeletal populations), and on the expectation of a close similarity between a pre- contact or early post-contact New Zealand life table and those from Polynesia presented by Kirch (1984: 112–114). The life table constructed here for the prehistoric period supports this view.

The adjusted New Zealand prehistoric life table is most like Coale and Demeny's (1966) West 2 or West 3 model tables when compared to their full range of model tables. The West 2 profile has a life expectancy at birth of 22.5 years and an infant mortality rate of 334 per thousand. The West 3 model profile has a slightly higher life expectancy at birth of 25 years and an infant mortality rate of 305 per thousand. Of these two, the better fit with regard to life expectancy at birth is the West 2 model.

Weiss's (1973) model tables, derived from small scale populations and prehistoric skeletal samples, may be a more appropriate standard for comparison with the New Zealand series than the broad scale regional model tables of Coale and Demeny (1966). The revised life tables for prehistoric New Zealand show most similarity to tables with life expectancy at age 15 of 15 years and survivorship at age 15 of 45 or 50 percent (Weiss 1973: 118–9). The infant mortality rates given in these tables are 300 and 267 per thousand respectively.

It must be noted, however, that the unusually high mortality in the 20–29 age group makes it difficult to match the New Zealand life table closely to any model table and it is unlikely that a closer fit will ever be possible.

CONCLUSIONS

Skeletally derived life tables are a valuable means to examine the prehistoric demography of New Zealand with a view to reconstructing accurate infant mortality levels. These life tables also allow more accurate estimation of various aspects of mortality, especially life expectancy at birth and age specific mortality, than previous estimates of length of life in prehistoric New Zealand which based their calculation of longevity on average age at death.

The calculated life table for prehistoric New Zealand highlights the problems of infant under-representation in the archaeological record, and provides a tool for the inference of reasonable infant mortality levels. The life tables adjusted to allow for this sample bias indicate a life expectancy at birth for prehistoric New Zealanders of between about 19 and 24 years.

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APPENDIX 1
SOURCES OF THE SAMPLE USED IN THE CONSTRUCTION OF A PREHISTORIC NEW ZEALAND LIFE TABLE

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KEY TO TABLES

Life tables for prehistoric New Zealand were constructed using the following formulae:

x = the age interval

D_x = the raw number of individuals assigned to the age interval

d_x = the standardised number of individuals assigned to the age interval based on a cohort of 100

$$= \frac{D_x}{\sum D_x} \times 100$$

l_x = survivorship to the age interval

$$= l_{x-1} - d_{x-1}$$

q_x = probability of dying in the age interval

$$= \frac{d_x}{l_x}$$

L_x = the number of years lived by survivors between ages x and $x + 1$

$$= \frac{(l_x + l_{x+1}) \times \text{ number of years in the age interval}}{2}$$

T_x = the number of years that can be lived from the beginning of the age interval until all have died

$$= (\sum L_x) - L_x$$

e_x^o = life expectancy at the beginning of the age interval

$$= \frac{T_x}{l_x}$$

TABLE 1
LIFE TABLE FOR PREHISTORIC NEW ZEALAND

x	D_x	d_x	l_x	q_x	L_x	T_x	e_x^o
0–1	6	3.49	100.0	0.035	98.3	2670.3	26.70
1–4	10	5.81	96.5	0.060	374.4	2572.1	26.65
5–9	7	4.07	90.7	0.045	443.3	2197.7	24.23
10–14	8	4.65	86.6	0.054	421.5	1754.4	20.25
15–19	10	5.81	82.0	0.071	395.3	1332.8	16.26
20–24	32	18.60	76.2	0.244	334.4	937.5	12.31
25–29	31	18.02	57.6	0.313	242.7	603.2	10.48
30–34	19	11.05	39.5	0.279	170.1	360.5	9.12
35–39	25	14.53	28.5	0.510	106.1	190.4	6.68
40–44	12	6.98	14.0	0.500	52.3	84.3	6.04
45–49	7	4.07	7.0	0.583	24.7	32.0	4.58
50–54	5	2.91	2.9	1.000	7.3	7.3	2.50

Total = 172 individuals

TABLE 2
LIFE TABLE FOR PREHISTORIC NEW ZEALAND WITH INTRODUCED INFANT MORTALITY RATE OF 153 PER THOUSAND

x	D_x	d_x	l_x	q_x	L_x	T_x	e_x^o
0–1	30	15.31	100.0	0.153	92.3	2349.5	23.49
1–4	10	5.10	84.7	0.060	328.6	2257.1	26.65
5–9	7	3.57	79.6	0.045	389.0	1928.6	24.23
10–14	8	4.08	76.0	0.054	369.9	1539.5	20.25
15–19	10	5.10	71.9	0.071	346.9	1169.6	16.26
20–24	32	16.33	66.8	0.244	293.4	822.7	12.31
25–29	31	15.82	50.5	0.313	213.0	529.3	10.48
30–34	19	9.69	34.7	0.279	149.2	316.3	9.12
35–39	25	12.76	25.0	0.510	93.1	167.1	6.68
40–44	12	6.12	12.2	0.500	45.9	74.0	6.04
45–49	7	3.57	6.1	0.583	21.7	28.1	4.58
50–54	5	2.55	2.6	1.000	6.4	6.4	2.50

Total = 196 individuals

TABLE 3
LIFE TABLE FOR PREHISTORIC NEW ZEALAND WITH INTRODUCED INFANT MORTALITY RATE OF 198 PER THOUSAND

x	D_x	d_x	l_x	q_x	L_x	T_x	e_x^o
0–1	41	19.81	100.0	0.198	90.1	2227.3	22.27
1–4	10	4.83	80.2	0.060	311.1	2137.2	26.65
5–9	7	3.38	75.4	0.045	368.4	1826.1	24.23
10–14	8	3.86	72.0	0.054	350.2	1457.7	20.25
15–19	10	4.83	68.1	0.071	328.5	1107.5	16.26
20–24	32	15.46	63.3	0.244	277.8	779.0	12.31
25–29	31	14.98	47.8	0.313	201.7	501.2	10.48
30–34	19	9.18	32.9	0.279	141.3	299.5	9.12
35–39	25	12.08	23.7	0.510	88.2	158.2	6.68
40–44	12	5.80	11.6	0.500	43.5	70.0	6.04
45–49	7	3.38	5.8	0.583	20.5	26.6	4.58
50–54	5	2.42	2.4	1.000	6.0	6.0	2.50

Total = 207 individuals

TABLE 4
LIFE TABLE FOR PREHISTORIC NEW ZEALAND WITH INTRODUCED INFANT MORTALITY RATE OF 249 PER THOUSAND

x	D_x	d_x	l_x	q_x	L_x	T_x	e_x^o
0–1	55	24.89	100.0	0.249	87.6	2089.4	20.89
1–4	10	4.52	75.1	0.060	291.4	2001.8	26.65
5–9	7	3.17	70.6	0.045	345.0	1710.4	24.23
10–14	8	3.62	67.4	0.054	328.1	1365.4	20.25
15–19	10	4.52	63.8	0.071	307.7	1037.3	16.25
20–24	32	14.48	59.3	0.244	260.2	729.6	12.31
25–29	31	14.03	44.8	0.313	188.9	469.5	10.48
30–34	19	8.60	30.8	0.279	132.4	280.5	9.12
35–39	25	11.31	22.2	0.510	82.6	148.2	6.68
40–44	12	5.43	10.9	0.500	40.7	65.6	6.04
45–49	7	3.17	5.4	0.583	19.2	24.9	4.58
50–54	5	2.26	2.3	1.000	5.7	5.7	2.50

Total = 221 individuals

TABLE 5
LIFE TABLE FOR PREHISTORIC NEW ZEALAND WITH INTRODUCED INFANT MORTALITY RATE OF 297 PER THOUSAND

x	D_x	d_x	l_x	q_x	L_x	T_x	e^o_x
0–1	70	29.66	100.0	0.297	85.2	1959.7	19.60
1–4	10	4.24	70.3	0.060	272.9	1874.6	26.65
5–9	7	2.97	66.1	0.045	323.1	1601.7	24.23
10–14	8	3.39	63.1	0.054	307.2	1278.6	20.25
15–19	10	4.24	59.7	0.071	288.1	971.4	16.26
20–24	32	13.56	55.5	0.244	243.6	683.3	12.31
25–29	31	13.14	41.9	0.313	176.9	439.6	10.48
30–34	19	8.05	28.8	0.279	123.9	262.7	9.12
35–39	25	10.59	20.8	0.510	77.3	138.8	6.68
40–44	12	5.08	10.2	0.500	38.1	61.4	6.04
45–49	7	2.97	5.1	0.583	18.0	23.3	4.58
50–54	5	2.12	2.1	1.000	5.3	5.3	2.50

Total = 236 individuals

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