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ABORIGINAL MORTALITY IN CANADA, THE UNITED STATES AND NEW ZEALAND

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Summary. Indigenous populations in New World nations share the common experience of culture contact with outsiders and a prolonged history of prejudice and discrimination. This historical reality continues to have profound effects on their well-being, as demonstrated by their relative disadvantages in socioeconomic status on the one hand, and in their delayed demographic and epidemiological transitions on the other. In this study one aspect of aboriginals' epidemiological situation is examined: their mortality experience between the early 1980s and early 1990s. The groups studied are the Canadian Indians, the American Indians and the New Zealand Maori (data for Australian Aboriginals could not be obtained). Cause-specific death rates of these three minority groups are compared with those of their respective non-indigenous populations using multivariate log-linear competing risks models. The empirical results are consistent with the proposition that the contemporary mortality conditions of these three minorities reflect, in varying degrees, problems associated with poverty, marginalization and social disorganization. Of the three minority groups, the Canadian Indians appear to suffer more from these types of conditions, and the Maori the least.

Introduction

Aboriginal populations of New World nations share widespread socioeconomic disadvantages and a prolonged history of prejudice and discrimination. These conditions are tied to their historical experience of culture contact with the outsiders (Bienvenue, 1983; Lieberson, 1961; Livi-Bacci, 1992; Simpson & Yinger, 1985; Young, 1994). This study examines one aspect of the historical legacy of culture contact: the aboriginals' relatively poor survival conditions in a context of delayed demographic and epidemiological transitions. Cause-specific mortality rates are analysed for the Canadian Registered Indians, the American Indians and the New Zealand Maori in relation to the corresponding non-aboriginal counterparts in the three societies. The principal objectives of the study are: (1) to ascertain the magnitude of mortality gaps between aboriginals and non-aboriginals in Canada, the United States and New

Zealand; (2) to determine in which of these countries the overall and cause-specific mortality gaps are most pronounced; (3) to see whether the differences in the mortality experience between aboriginals and non-aboriginals in the three nations have narrowed or possibly widened over the study interval; and (4) to document the causes of death responsible for the gaps in mortality risks between the minority groups and their respective national societies. It would have been desirable to include in this study Australian Aboriginals and their respective non-Aboriginal population. Unfortunately, such data could not be obtained. This poses a limitation to this investigation, as Australian Aborigines suffer wide mortality discrepancies in relation to their larger society; and their survival deficit tends to be more pronounced than that of aboriginals in Canada, the United States and New Zealand (Hogg, 1992; Kunitz, 1990, 1994; Taylor, 1997).

Aboriginal mortality patterns

A number of common themes emerge in the relevant literature concerning aboriginal mortality. Notwithstanding long-term gains in both overall and infant death rates, aboriginals continue to suffer lower life expectancies as compared with their national populations. They tend to share a disproportionate risk of premature death from accidents, violence and suicide, while at the same time over recent decades there has been a rising incidence of chronic/degenerative conditions (i.e. cardiovascular disease and to a lesser extent cancer). Aboriginal death rates from infectious and communicable diseases also tend to be disproportionately high in relation to their larger societies (Broudy & May, 1983; Young, 1994; Kunitz, 1983, 1990, 1994; Pool, 1991, 1994; Honari, 1990; Jarvis & Boldt, 1982; Mao *et al.*, 1986, 1992; Morrison *et al.*, 1986; Bobet, 1989; Young, 1983, 1994; Trovato, 1988; Royal Commission on Aboriginal Peoples, 1995; Hisnanick, 1994; Bachman, 1992; Grey, 1990; Hogg & Thomson, 1992). These features of aboriginal mortality indicate that their epidemiological patterns are at variance with those of their respective national societies.

According to the theory of epidemiological transition, societies experience over time three stages of development with regard to their pattern of disease dominance (Omran, 1971). Ancient societies went through the 'age of pestilence and famine', dominated by frequent famines, wars, violence, plague and other lethal infectious and parasitic diseases, which combined to claim individuals relatively early in life. The second stage of transition, 'the age of receding pandemics', featured a progressive recession of such disease pandemics and the eventual disappearance of plague. By the turn of the 20th century Western society had entered the third stage, that of 'man-made and degenerative diseases', where the average length of life increased to historically high levels, as a result of successes in eradicating many of the lethal viral and parasitic diseases of the past through the invention of modern medicine in conjunction with better diets, hygiene and standards of living. The leading killers in this stage become cancer and heart disease, conditions associated with increased longevity, demographic aging, and some health-eroding life style habits, including smoking, substance abuse and a more sedentary life (Olshansky & Ault, 1986; Rogers & Hackenberg, 1987).

Currently, the demographic and epidemiological transitions of aboriginal populations tend to be closer to those of some contemporary developing nations than to their respective larger societies. For instance, Pool (1994, p. 17) places the New Zealand Maoris in the 'transitional' stage of epidemiologic transition, to denote that notwithstanding this group's location in a highly advanced nation, its epidemiological profile is more characteristic of the second stage than the third. Young (1983) reaches a similar conclusion in relation to Canadian Indians, as do Broudy & May (1983) with reference to the American Indians.

In fact, as compared with their larger societies, aboriginal birth and overall death rates tend to be notably higher; and they also share a greater than expected prevalence of infectious and parasitic diseases, especially among infants and children. Among adult aboriginals, the level of premature death as a result of accidents, suicide and violence is disturbingly high (Honari, 1990; Jarvis & Boldt, 1982; Levy & Kunitz, 1971; Mao *et al*., 1992; Young, 1994; Pool, 1991; Royal Commission on Aboriginal Peoples, 1995; Hisnanick, 1994; Bachman, 1992).

To a large extent, the origins of these problems can be traced back to the aboriginals' experience of culture contact with the Europeans and the aftermath of that encounter (Bienvenue, 1983; Lieberson, 1961; Livi-Bacci, 1992; Romaniuc, 1995; Simpson & Yinger, 1985). As a result of their geographic, socioeconomic and social psychological marginalization, many aboriginal communities have unusually high levels of social disorganization, exacerbated by high rates of alcoholism and other substance abuse. In the case of Canadian Indians, Whitehead & Hayes (1998) have determined that alcohol is a prime factor in the explanation of social problems in this population. In the Australian context, Gladman and colleagues (1997) report that alcohol is implicated as a direct cause of approximately 10% of deaths among aboriginal people. In a further proportion of aboriginal deaths alcohol plays a partial role. Overall, in relation to the larger Australian society, the proportion of deaths that are alcohol related among the Aborigines is three to five times higher. Other scholars of aboriginal health in New World nations have noted the critical role of alcohol in premature mortality, family violence and crime (Bachman, 1992; Broudy & May, 1983; Cercarelli, 1994; De Wit, Embree & De Wit, 1997; Jarvis & Boldt, 1982; Levy & Kunitz, 1971; Moore, 1992; Morrison *et al*., 1986).

Recently, aboriginal populations are being faced with a new problem: as they undergo rapid modernization and sustained fertility declines, they are experiencing the beginning of an epidemic of chronic/degenerative diseases and disabilities (Kunitz, 1990; Romaniuc, 1987; Jaffe, 1992; Pool, 1994; Ng, 1996). This development entails a shift-share between communicable and non-communicable diseases, as the former tend to recede, while the latter increase, with advancing modernization and accompanying improvements in the standards of living (Pool, 1994).

From these observations one may anticipate that aboriginal mortality levels in the three nations in this analysis will be significantly higher than their non-aboriginal counterparts. It is also possible that notwithstanding some improvements in survival over recent decades, in relation to their larger societies aboriginal mortality risk may have actually gone up. In accordance with the literature in this area, it is also anticipated that accidents, violence and homicide will account for a disproportionate share of premature deaths among aboriginals. Finally, as these groups approach their

final stages of demographic and epidemiologic transitions, chronic/degenerative conditions such as circulatory diseases and cancers should rise significantly over time.

The three aboriginal groups may not share uniform relative mortality risks (viz. their respective national populations). Their societies are characterized by a number of differences, which may have bearing on differential mortality. For instance, New Zealand has a lower *per capita* income than both Canada and the United States (Population Reference Bureau, 1999), though income distribution is more equal than either Canada or the United States. New Zealand has a smaller population in relation to the other two nations, and the Maori represent a larger proportion of the population than do Indians in Canada and the United States. Moreover, the Maori all speak the same language, while the two North American aboriginal groups share a variety of Native languages. Thus, the Maori in New Zealand may represent a more unified political presence than is true of aboriginals in either Canada or the United States. In fact, according to Pool (1991, 1998) the Maori in New Zealand represent about 16% of the total population, and also occupy powerful and prestigious positions in government, ranging from Governor General down the administrative hierarchy. These facts suggest that Maori may not be as disadvantaged as their North American counterparts, and therefore it may be anticipated that out of the three groups, the relative mortality gap should be lowest for the New Zealand Maori. Evidence concerning the Indians of Canada indicates that they are highly disadvantaged in both social and economic terms (Anderssen, 1998; Boldt, 1993). A similar situation seems to prevail for the American Indians and Alaska Natives (Levy & Kunitz, 1971; Jaffe, 1992; Simpson & Yinger, 1985; Thornton, 1987; Williams & Collins, 1995). While these indications point to a greater survival disadvantage for the two North American groups, it is also true that the governments of Canada and the United States have implemented special provisions and services for the Indians, including free health care and education. These aspects of aboriginal condition suggest that, in a relative sense, the health of Canadian and American Indians should perhaps be similar to that of Maoris.

Data and methods

Canadian Indian data (deaths and populations) were obtained from Health Canada, Medical Service Branch (1995) and pertain to the Registered Indians of Canada during 1979–83 and 1990–92 (population is for the central years of these two periods). The data for American Indians were received from the United States Department of Health and Human Service, Office of Public Health, Indian Health Service, Program Statistics Team, Demographic Statistics (1995), and include both mortality and corresponding populations for the American Indians and Alaska Natives as one group, for the periods of 1979–81 and 1989–91 (populations for 1980 and 1990, respectively). Maori and non-Maori deaths and populations were supplied by New Zealand Department of Statistics (1995), and correspond to 3-year death counts surrounding 1981 and 1991 censuses, respectively. Data for non-indigenous Canadians for 1981 and 1991 are from a special tabulation provided by Statistics Canada (1996). Non-Indian data for the United States for 1980 and 1990 were obtained from the World Health Organization (1996) (Indian mortality and population figures were subtracted accordingly from the overall American population).

Data quality issues

Mortality statistics are often plagued by problems of incompleteness, particularly in the case of ethnic populations (Rosenwaike, 1992). There are also issues of accuracy in defining race and ethnicity in vital statistics and census records. Official identification of Indians in Canada and the United States and Maori in New Zealand is usually based on one or more of the following criteria, depending on the circumstance: (1) self-identification by the individual, as in the case of the census; (2) racial identification of decedents by a coroner/physician and by an informant (often a spouse, sibling or close relative of the deceased person) in the case of deaths; (3) administrative linkage and matching of decedents' records (e.g. death certificate or other official record) to one's census return on the basis of legal aboriginal status (i.e. Status Indian, or American/Alaska Indian or Maori).

Clearly, some degree of caution needs to be exercised in interpreting statistical results based on official aboriginal data. Hogg (1992) has warned that aboriginal data tend to suffer from some inconsistencies. Population figures can increase rather unrealistically from census to census, reflecting to a large extent changes in self-identification among Aboriginals in the census. For instance, in the American context, part of the significant increase in the American Indian population over the last several decades can be attributed to a growing tendency for indigenous persons to self-identify as Indian, due to a resurgence of Native cultural pride (Thornton, 1981; Nagel, 1995). Regarding the Maoris, Pool (1991, pp. 19–20) has said that: 'Statistical definitions until the 1986 census generally employed a biological base, using the criterion of half or more Maori ''blood''. There have been variations over time and between sources, and even some inconsistencies in the major demographic data base, the census. Throughout its history . . . the New Zealand population has been divided broadly into Maori and non-Maori statistical components, the latter including persons of European, Asian, Pacific Island Polynesian and other origins. The term ''New Zealand Maori'' refers to persons from ''geographic New Zealand'' and has always specifically excluded Cook Island Maori, who have been classified as non-Maori. This broad dichotomy accepted, difficulties abound around exact cut-off points.'

Problems regarding definition of race in the census and the vital statistics registration systems may be more acute in the context of the United States and Canada than in New Zealand. In the former countries the census is likely to include persons who identify themselves as aboriginal and are easily linked into bands/reserves; however, in the case of vital statistics data, a significant number of 'Indians' may well die away from reserves, say in large urban areas, and are not recognized as such by coroners (and can't of course themselves identify as Indian). Thus, computed death rates may represent deflated estimates of true mortality levels for both American and Canadian Indians. This problem may be particularly pronounced in the case of Canadian Indians, as their mortality data are seldom complete due to problems of undercoverage of the population and late reporting of vital events (Health Canada, 1996, pp. 2–5).

Statistical procedures

Deaths were classified into nine cause categories in accordance with the corresponding International Classification of Disease codes for both the early 1980s and

the early 1990s: (1) infectious and parasitic diseases (ICD-8 codes 001.0 to 136.9; ICD-9 codes 001.0 to 139.9); (2) respiratory diseases (ICD-8 and ICD-9 codes 460.0 to 519.9); (3) diseases of the circulatory system (ICD-8 codes 390.0 to 458.9; ICD-9 codes 390.0 to 459.9); (4) neoplasms (ICD-8 and ICD-9 codes 140.0 to 239.0); (5) suicide (ICD-8 and ICD-9 codes E950.0 to E959.9); (6) homicide (ICD-8 and ICD-9 codes E960.0 to E978.9); (7) motor vehicle fatalities (ICD-8 codes E810.0 to E823.9; ICD-9 codes E810.0 to E825.9); (8) other external causes (ICD-8 and ICD-9 codes E800.0 to E807.9; E825–0 to E949.0; E980 to E999.9); (9) all other causes of death (residual). Given the importance of alcohol abuse in aboriginal mortality, it would have been desirable to include this specific cause of death in the analysis; unfortunately, this information is unavailable in the data file.

The analysis begins with a presentation of some basic descriptive demographic measures for the three aboriginal groups and their respective national populations; this is then followed by a multivariate analysis of mortality rates, adopting a methodology developed by Laird & Olivier (1981), later extended by Larson (1984). Maximum likelihood log-linear competing risk models are fitted to the mortality and population data under the assumptions that cause-of-death categories compete independently in claiming lives in the populations at risk, and that the occurrence of deaths in the population is Poisson distributed (Laird & Olivier, 1981; Larson, 1984; Clogg & Eliason, 1987; Agresti, 1990).

To illustrate, the following equation treats cause of death as a predictor of the overall death rate. This model can be easily modified to allow interactions of cause of death with racial/ethnic group and any other predictor:

$$\ln(D^*_{ijklmn}/P_{ijklmn}) = a + \lambda_i^{\mathrm{AGE}} + \lambda_j^{\mathrm{SEX}} + \lambda_k^{\mathrm{TIME}} + \lambda_l^{\mathrm{CAUSE}} + \lambda_m^{\mathrm{GROUP}} + \lambda_n^{\mathrm{COUNTRY}}$$

D^*_{ijklmn} values are expected deaths under this model by age, sex, time, cause, ethnic/racial group and country; P_{ijklmn} values are the corresponding populations at risk. The lambda (λ) parameters in the equation share the constraint: $\Sigma\lambda_i = \Sigma\lambda_j = \Sigma\lambda_k = \Sigma\lambda_l = \Sigma\lambda_m = \Sigma\lambda_n = 0$. The definition of variables is as follows: Age (1 = 0, 2 = 1–4, 3 = 5–14, 4 = 15–24, 5 = 25–34, 6 = 35–44, 7 = 45–54, 8 = 55–64, 9 = 65–74, 10 = 75+); Sex (1 = female, 2 = male); Time Period (1 = early 1980s, 2 = early 1990s); Cause of Death (1 = infectious/parasitic, 2 = respiratory, 3 = circulatory, 4 = neoplasms, 5 = suicide, 6 = homicide, 7 = motor vehicle accidents, 8 = all other accidents and violence, 9 = all other causes of death); Ethnic/Racial Group (1 = aboriginal, 2 = non-aboriginal); Country (1 = Canada, 2 = United States, 3 = New Zealand). The constant term, a, is the overall average of log of death rates. The lambdas measure the effect of being in a category of a given predictor to either raising or lowering the overall expected death rate.

Analysis

Descriptive overview

Tables 1 and 2 include crude and age-standardized death rates (direct method) for the aboriginal groups and their corresponding national populations, as well as additional demographic indicators for 1981 and 1991. In each of the three societies crude death rates of aboriginals are lower than those of their non-aboriginal counterparts; this distortion is caused by the effects of aboriginal higher fertility,

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Table 1. Basic demographic measures for the registered Indians of Canada, the American Indians and the New Zealand Maori around 1981 and 1991

	Canada		USA		New Zealand	
	Males	Females	Males	Females	Males	Females
1981						
CDR	7·79	4·89	7·83	4·75	5·33	4·07
ASDR	13·07	8·94	11·91	6·87	15·12	11·15
Life expectancy	62·4	68·9	67·1	75·1	65·2	68·3
IMR	21·8		15·4		17·8	
CBR	27·0		28·1		24·0	
CWR	495·9		493·3		514·4	
Population *n*	141,941	138,016	418,612	431,607	140,190	139,460
% <15	38·4		34·7		39·4	
% 15–64	57·5		59·7		58·2	
% 65+	4·1		5·6		2·4	
1991						
CDR	6·86	4·52	6·27	4·29	5·01	3·72
ASDR	12·71	7·95	10·01	6·05	11·89	8·40
Life expectancy	66·9	74·0	69·8	77·4	67·2	72·3
IMR	12·3		10·2		14·1	
CBR	29·5		29·3		22·0	
CWR	404·2		506·9		473·6	
Population *n*	196,933	200,055	594,975	613,473	161,000	162,810
% <15	34·4		33·7		33·1	
% 15–64	62·7		60·5		63·9	
% 65+	3·8		5·7		3·0	

The standard for Age-Standardized Death Rates (ASDR) is the combined populations of the three nations in the earlier period. Deaths are averages for the following periods: 1979–83 and 1990–91 for Canadian Indians; 1979–81 and 1989–91 for American Indians; 1980–82 and 1990–92 for Maoris. Corresponding census populations are for the central years. Crude Birth Rates (CBR) taken from: Health Canada (1996, p. 9); US Department of Health and Human Services, Indian Health Service (1994, p. 33); Pool (1991, p. 167). Infant Mortality Rates (IMR) computed from data provided by the three national statistical bureaus (see text). Life expectancy for American Indians in 1980 taken from Jaffe (1992, p. 164); for 1990, estimated using assumed change of a 2·7-year increase for Indian men and a 2·3-year gain for Indian women. Life expectancy for Canadian Indians taken from Norris (1996, p. 3). Life expectancy for Maoris in 1981 taken from Kunitz (1990, p. 650); for 1991 figures estimated assuming a gain of 2 years for males and 4 for females. Child Women Ratios (CWR) calculated from respective age-specific census populations.

and correspondingly, younger age structures. Not surprisingly, once the confounding effects of age composition have been taken into account through standardization, aboriginal death rates are actually higher than their respective national populations. Their infant mortality rates exceed those of non-aboriginals; and their

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Table 2. Basic demographic measures for the non-aboriginal populations of Canada, The United States and New Zealand around 1981 and 1991

	Canada		USA		New Zealand	
	Males	Females	Males	Females	Males	Females
1981						
CDR	8·22	6·18	9·78	7·86	9·37	7·79
ASDR	10·67	6·62	10·98	6·58	12·93	7·11
Life expectancy	71·9	78·9	70·1	77·6	70·4	76·6
IMR	9·6		12·6		11·3	
CBR	14·9		15·9		15·8	
CWR	301·8		312·2		308·1	
Population *n*	11,803,866	11,973,631	109,979,300	116,371,500	1,409,130	1,447,930
% <15	22·8		22·6		25·0	
% 15–64	68·4		66·2		64·4	
% 65+	9·1		11·2		10·6	
1991						
CDR	7·95	6·61	9·28	8·16	8·80	7·70
ASDR	8·49	5·28	9·71	6·13	9·33	6·05
Life expectancy	74·6	80·9	71·8	78·8	71·6	77·6
CBR	14·3		15·5		17·5	
CWR	290·2		317·8		333·3	
IMR	6·4		9·2		7·1	
Population *n*	13,257,642	13,642,240	120,643,900	126,856,400	1,517,240	1,565,190
% <15	20·6		21·6		22·2	
% 15–64	67·6		66·0		65·7	
% 65+	11·7		12·4		12·1	

The standard for Age-Standardized Death Rates (ASDR) is the combined populations of Canada, United States and New Zealand in the earlier period. Crude Birth Rates (CBR) and Infant Mortality Rates (IMR) taken from: Health Canada (1996, p. 9); US Department of Health and Human Services, Indian Health Service (1994, p. 33); Pool (1991, p. 167); United Nations *Demographic Yearbooks for 1992 and 1985*. Infant Mortality Rates for non-Maoris calculated with data provided by New Zealand Bureau of Statistics. Life expectancy figures taken from United Nations *Demographic Yearbooks* (various years). Child Women Ratios (CWR) calculated from respective age-specific census populations.

life expectancies are below their larger societies. While all six populations in this analysis have enjoyed varying degrees of mortality declines between 1981 and 1991, mortality differentials are far from being eliminated.

Multivariate analysis

Since the age pattern of mortality in human populations is not uniform, this part of the analysis is partitioned into four parts: (1) adults 15 and older; (2) infants; (3) early childhood, ages 1–4; and (4) late childhood, ages 5–14.

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Adult mortality (ages 15 and older). In Table 3, separate log-linear equations were executed for each nation. In the cases of Canada and the United States, a very good fit is provided by a model which contains main effects and first-order interactions of ethnicity with cause of death, as well as interactions of age and cause, period and age and period with cause. For New Zealand, the period–ethnic cause interactions turned out to be statistically irrelevant. The effect of aboriginal ethnicity on overall mortality is strongest in Canada ($\lambda = 0{\cdot}430$), whereas in the United States and New Zealand the corresponding terms are about half this value (0·223 and 0·201, respectively). By exponentiating the lambda terms in the equation, multiplicative effects of predictor variables on the overall death rate are derived. Thus, using the aboriginal main effects, their exponentiated values indicate that being aboriginal multiplies the overall expected death rate by 1·54 for the Canadian Indians, and by 1·25 and 1·22 for American and New Zealand aboriginal groups. By taking the inverse of these terms the multipliers for the non-aboriginal in Canada, the United States and New Zealand are obtained, and are computed to be: 0·65, 0·80 and 0·82, respectively. Aboriginal relative risks can be computed by dividing the aboriginal multipliers by those of non-aboriginals. The computed relative risks are 2·37, 1·56 and 1·49 for Canadian, American and New Zealand aboriginals, respectively.

Looking at the ethnicity–cause of death interactions, the direction of parameter values in Canada and the United States suggests that Indians in these two societies share a common pattern of mortality risk. In both countries they have relatively low risks of premature death due to neoplasms, circulatory ailments and respiratory conditions. These types of mortality are typically more prevalent in aging populations. However, the risks for these two aboriginal groups are elevated in the cases of suicide, homicide, motor vehicle accidents (USA), other accidents/violence and infectious/parasitic diseases (USA). Suicide and homicide appear to be more significant problems for the Canadian Indians than for Indians in the United States, while motor vehicle fatalities are a more common cause of premature death in the American group.

Maoris exhibit a cause-of-death pattern that is different from their two North American counterparts. The leading killers of Maoris are not accidents, violence or suicide, but rather infectious/parasitic diseases, respiratory problems, homicide and circulatory conditions. A significant similarity of Maoris with the two North American groups lies in connection with their high rates of homicide.

The interaction of time with ethnicity shows that between 1981 and 1991 both Canadian and American Indians experienced small drops (by about 3 and 4%, respectively) in their overall death rates. However, the declines were not uniform across all cause-of-death categories; in some cases the improvement is more pronounced than in others. For the Canadian Indians improvements are noted in connection with infectious/parasitic diseases, suicide and other accidents/violence, but there were increases in risk due to circulatory ailments, neoplasms and motor vehicle accidents. No change seems to have occurred with regard to respiratory and homicide mortality. In the case of American Indians, declines in risk are observed for infectious/parasitic diseases and homicide; however, increases are shown in connection with respiratory conditions, circulatory ailments and neoplasms. Their mortality risk for suicide, motor vehicle accidents and other accidents/violence did not change significantly over time.

Table 3. Log-linear parameters for adult mortality (ages 15+), by country

Terms	Canada	USA	New Zealand
Constant	−4·8717	−4·6719	−4·7559
Aboriginal (vs non-aboriginal)	0·430*	0·231*	0·201*
1981 (vs 1991)	0·079*	0·059*	0·053*
Infectious/parasitic	−1·357*	−1·179*	−1·202*
Respiratory	−0·363*	−0·298*	0·396*
Circulatory	1·108*	1·203*	1·862*
Neoplasms	1·065*	0·958*	1·711*
Suicide	−0·175*	−0·744*	−0·864*
Homicide	−1·799*	−1·281*	−2·632*
Motor vehicle accidents	−0·281*	−0·053*	−0·251*
Other accidents/violence	0·549*	0·081*	−0·089*
(All other causes)	[1·253]	[1·313]	[1·067]
Female (vs male)	−0·357*	−0·392*	−0·303*
Age 15–24	−1·482*	−1·513*	−1·346*
25–34	−1·104*	−1·026*	−1·043*
35–44	−0·637*	−0·574*	−0·701*
45–54	−0·121*	−0·078*	−0·185*
55–64	0·418*	0·415*	0·331*
65–74	0·968*	0·943*	0·989*
(75+)	[1·958]	[1·833]	[1·955]
Aboriginal, infectious/parasitic (vs non-aboriginals)	−0·051	0·175*	0·248*
Aboriginal, respiratory (vs non-aboriginals)	−0·204*	−0·181*	0·137*
Aboriginal, circulatory (vs non-aboriginals)	−0·428*	−0·371*	0·038*

Table 3. *Continued*

Terms	Canada	USA	New Zealand
Aboriginal, neoplasms (vs non-aboriginals)	−0·687*	−0·438*	−0·066*
Aboriginal, suicide (vs non-aboriginals)	0·251*	0·038*	−0·421*
Aboriginal, homicide (vs non-aboriginals)	0·541*	0·053*	0·121
Aboriginal, motor vehicle accidents (vs non-aboriginals)	0·003	0·322*	−0·061*
Aboriginal, other accidents/violence (vs non-aboriginals)	0·418*	0·282*	−0·170*
(Aboriginal, all other causes) (vs non-aboriginals)	[1·738]	[0·120]	[0·174]
Aboriginal, 1981 (vs non-aboriginal, 1981)	0·031*	0·042*	
Aboriginal, 1991 (vs non-aboriginal, 1991)	[−0·031]	[−0·042]	
Aboriginal, 1981, infectious/par. (vs non-ab., 1981)	0·308*	0·056*	
Aboriginal, 1981, respiratory (vs non-ab., 1981)	−0·023	−0·030*	
Aboriginal, 1981, circulatory (vs non-ab., 1981)	−0·105*	−0·072*	
Aboriginal, 1981, neoplasms (vs non-ab., 1981)	−0·088*	−0·071*	
Aboriginal, 1981, suicide (vs non-ab., 1981)	0·086*	0·006	
Aboriginal, 1981, homicide (vs non-ab., 1981)	0·024	0·038*	
Aboriginal, 1981, motor vehicle accidents (vs non-ab., 1981)	−0·124*	0·008	
Aboriginal, 1981, other accidents/violence (vs non-ab., 1981)	0·080*	−0·009	
(Aboriginal, 1981, all other causes) (vs non-ab., 1981)	[−0·158]	[0·074]	
Pseudo R^2/df	0·993/161	0·995/161	0·993/87

*$p<0·05$.

In this and subsequent tables, values in brackets are the negative sums of parameters for a given variable. Redundant terms are left out of the interactions (e.g. in the case of ethnic by cause, only the aboriginal terms are shown; non-aboriginal coefficients can be derived as the negative values of those for aboriginals). Interaction terms not involving ethnicity not shown. Pseudo R^2 measures goodness of fit of a model, its range being between 0 and 1·000 (the higher the value, the better the fit).

Table 4. Log-linear parameters for age group 0–1, by country

Terms	Canada	USA	New Zealand
Constant	−5·0137	−4·6719	−4·7559
Aboriginal (vs non-aboriginal)	0·551*	0·257*	0·219*
1981 (vs 1991)	0·359*	0·181*	0·195*
Infectious/parasitic	0·007	−0·095	−0·313*
Respiratory	1·099*	0·597*	1·213*
Circulatory	−0·239	0·074	−0·752*
Neoplasms	−1·367*	−2·070*	−1·284*
Homicide	−2·381*	−1·128*	−1·633*
Motor vehicle accidents	−1·479*	−1·189*	−1·228*
Other accidents/violence	0·557*	0·258*	0·143*
(All other causes)	[3·807]	[3·553]	[3·854]
Female (vs male)	−0·109*	−0·114*	−0·130*
Aboriginal, 1981 (vs non-aboriginal, 1981)	0·159*	0·043*	
Aboriginal, 1991 (vs non-aboriginal, 1991)	[−0·159]	[−0·043]	
Aboriginal, infectious/parasitic (vs non-ab.)	0·528*	0·111	
Aboriginal, respiratory (vs non-ab.)	0·486*	0·096	
Aboriginal, circulatory (vs non-ab.)	0·285*	−0·091	
Aboriginal, neoplasms (vs non-ab.)	−0·226	−0·443*	
Aboriginal, homicide (vs non-ab.)	−0·822	0·045	
Aboriginal, motor vehicle accidents (vs non-ab.)	−0·338	0·240*	
Aboriginal, other accidents/violence (vs non-ab.)	0·266*	0·241*	
(Aboriginal, all other causes) (vs non-ab.)	[−0·179]	[−0·199]	
Pseudo R^2/df	0·996/18	0·999/18	0·900/10

*$p<0·05$.

Mortality under 1 year of age. As shown in Table 4, the computed equations for Canada and the United States include main and interactions effects of ethnicity with time, and ethnicity with cause of death. For New Zealand, models containing interactions were insignificant. All three equations in the table indicate that infant death rates have declined over time, and that female infants have a lower likelihood of premature death as compared with boys by an almost equal degree across the three nations. Overall, the leading killers of infants are respiratory ailments and conditions that fall under the rubric of 'other accidents and violence' (e.g. poisonings, exposure, abuse, neglect) as well as 'other causes' (e.g. congenital anomalies, conditions associated with the birth process).

Being aboriginal increases an infant's relative risk of death, the risk being 2·99 for Canadian Indians, 1·66 for American Indians and 1·54 for Maoris. These varying levels of risk suggest that conditions are somewhat more problematic for the Canadian Indian infants. However, notwithstanding these mortality disadvantages, there is one optimistic trend: the interactions of ethnicity with time period show that between 1981 and 1991 mortality risk declined for both Canadian ($\lambda_{1991} = -0·159$) and American Indian ($\lambda_{1991} = -0·043$) infants. Canadian Indians are more likely to

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Table 5. Log-linear parameters for age group 1–4, by country

Terms	Canada	USA	New Zealand
Constant	−9·9706	−9·2347	−9·0791
Aboriginal (vs non-aboriginal)	0·291	0·247*	0·162
1981 (vs 1991)	0·068*	0·202*	0·309*
Infectious/parasitic	−0·525	−0·687*	−0·350
Respiratory	0·434	−0·389*	0·199
Circulatory	−0·419	−0·643*	−1·182*
Neoplasms	0·282	−0·591*	−0·198
Homicide	−0·915*	−0·644*	−1·080*
Motor vehicle accidents	−2·588	0·641*	0·337
Other accidents/violence	1·779*	1·191*	1·251*
(All other causes)	[1·952]	[1·122]	[1·023]
Female (vs male)	−0·132*	−0·133*	−0·162*
Aboriginal, 1981 (vs non-aboriginal, 1981)	−0·199*	0·051*	0·143*
Aboriginal, 1991 (vs non-aboriginal, 1991)	[0·199]	[−0·051]	[−0·143]
Aboriginal, infectious/parasitic (vs non-ab.)	0·488	0·119	0·382
Aboriginal, respiratory (vs non-ab.)	0·638*	0·029	0·452*
Aboriginal, circulatory (vs non-ab.)	0·312	−0·047	−0·024
Aboriginal, neoplasms (vs non-ab.)	−0·041	−0·461*	−0·613*
Aboriginal, homicide (vs non-ab.)	0·402	0·037	0·272
Aboriginal, motor vehicle accidents (vs non-ab.)	−3·222	0·423*	−0·054
Aboriginal, other accidents/violence (vs non-ab.)	0·816*	0·058	−0·121
(Aboriginal, all other causes) (vs non-ab.)	[0·607]	[−0·158]	[−0·294]
Pseudo R^2/df	0·986/23	0·990/23	0·956/23

*$p<0·05$.

die prematurely from infectious and parasitic diseases ($\lambda=0·528$), respiratory ailments ($\lambda=0·486$), circulatory problems ($\lambda=0·285$) and 'other' accidents/violence ($\lambda=0·266$). The leading mortality effects for the American Indians are motor vehicle accidents ($\lambda=0·240$) and 'other' accidents/violence ($\lambda=0·241$).

Mortality in the age group 1–4. Judging from the main effects of race/ethnicity on mortality in Table 5, in statistical terms being aboriginal is unimportant for 1–4-year-olds in both Canada and New Zealand. In the United States, however, Indian children suffer a disproportionate chance of premature death in relation to other Americans (relative risk = 1·56), though there was a small decline in this differential across time (by about 5%). Canadian Indians and Maoris also experienced small significant reductions in relative risk during the 1980s.

Young aboriginal children continue to share notable disadvantages with respect to some causes of death. Among Canadian Indians and Maoris, respiratory conditions claim a disproportionate number of 1–4-year-olds, whereas motor vehicle accidents constitute a serious problem for the American Indians. 'Other accidents and violence'

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Table 6. Log-linear parameters for age group 5–14, by country

Terms	Canada	USA	New Zealand
Constant	− 10·1910	− 10·0131	− 9·9868
Aboriginal (vs non-aboriginal)	0·404*	0·117*	− 0·071
1981 (vs 1991)	0·203*	0·123*	0·064
Infectious/parasitic	− 1·343*	− 1·131*	− 1·000*
Respiratory	− 0·761*	− 0·824*	− 0·093
Circulatory	− 0·584*	− 0·647*	− 0·576*
Neoplasms	0·315*	0·315*	0·803*
Suicide	0·043	− 1·066*	− 1·240*
Homicide	− 1·175*	− 0·404*	− 1·242*
Motor vehicle accidents	0·706*	1·334*	1·311*
Other accidents/violence	1·541*	1·355*	1·005*
(All other causes)	[1·258]	[1·068]	[1·032]
Female (vs male)	− 0·201*	− 0·204*	− 0·199*
Aboriginal, infectious/parasitic (vs non-aboriginals)	− 0·081	0·171	
Aboriginal, respiratory (vs non-aboriginals)	0·031	− 0·216	
Aboriginal, circulatory (vs non-aboriginals)	0·141	− 0·171	
Aboriginal, neoplasms (vs non-aboriginals)	− 0·640*	− 0·376*	
Aboriginal, suicide (vs non-aboriginals)	0·976*	0·179	
Aboriginal, homicide (vs non-aboriginals)	− 0·431*	0·013	
Aboriginal, motor vehicle accidents (vs non-aboriginals)	− 0·743*	0·150*	
Aboriginal, other accidents/violence (vs non-aboriginals)	0·539*	0·219*	
(Aboriginal, all other causes) (vs non-aboriginals)	[0·208]	[0·032]	
Pseudo R^2/df	0·931/21	0·952/21	0·900/11

*$p<0·05$.

account for a significant number of deaths among Canadian Indian children. In all three minority groups cancer is relatively rare in this age category.

Mortality in the age group 5–14. In this age group, both Canadian ($\lambda = 0{\cdot}404$) and American ($\lambda = 0{\cdot}117$) Indians share significant overall risks of premature death. The relative risk for Canadian Indians is 2·24, and for American Indians it is much lower, at 1·26. In New Zealand, race/ethnic membership *per se* has no effect on mortality. Across the three societies, accidents and violence (excluding suicide and homicide) and to a lesser extent, cancer, are the leading killers. A notable gender gap in mortality is seen across nations. There are significant interaction terms of race/ethnicity in the Canadian and American equations, though not for New Zealand. The leading causes of premature death for the Canadian Indians are suicide and accidents/violence (excluding homicide), while for the American Indians motor vehicle accidents and 'other' forms of accidents and violence (excluding homicide) account for a large part of their overall mortality disadvantage in relation to other Americans.

Discussion

Notwithstanding varying levels of improvements in the social and economic conditions of aboriginals in Canada, the United States and New Zealand, varying degrees of inequality in mortality persist in these societies. Though far from being uniform, the extent of this discrepancy is conspicuous across all four age categories examined in this analysis. This problem is most pronounced in the cases of Canadian and American Indians, though more so for the former. Of the three groups in this analysis, Maoris share a more favourable pattern of relative risks. Canadian and American Indians showed greater relative risks of premature death from conditions that are largely preventable and that also tend to be highly correlated with poverty, geographic isolation and social disorganization. For both these groups motor vehicle accidents, 'other accidents', suicide and homicide figured prominently as causes of early death among adults, and to a considerable extent also among young children and teenagers. For instance, for American Indian infants, 1–4- and 5–14-year-olds, motor vehicle accidents constitute a major source of concern; and for the Canadian Indians, teenage suicide remains a disturbing problem, as do 'other' forms of accidents and violence. Amidst these negative features, a positive development for these two groups is that adults' relative risk of infectious/parasitic diseases, suicide and homicide actually went down somewhat over the study interval.

During the 1980s these two populations experienced a rise in mortality risk due to respiratory ailments, circulatory disease and neoplasms (and motor vehicle accidents in the case of Canadian Indians). Given the inherent nature of circulatory and neoplastic diseases and the large number of deaths these ailments usually entail in the population, it would appear that these two groups (like their larger societies) are experiencing a corollary feature of population aging and rising life expectation – a rising incidence of chronic and degenerative diseases. As these groups proceed towards completion of their epidemiologic transitions, cancer and heart disease will gain even greater prominence as leading killers. This theme has already captured the attention of scholars (Kunitz, 1990, 1994; Broudy & May, 1983; Young, 1988a, b,

1994; Waldram, Herring & Young, 1995). As noted by Kunitz (1990), this development poses a considerable challenge to both the aboriginal communities and the health care systems of their larger societies.

The situation for the Maoris appears to have parallels as well as some differences with the situations of the two North American aboriginal groups. For instance, like their Canadian and American counterparts, in the multivariate analysis of adult mortality, the ethnic effect for Maoris was substantial (though lower in magnitude than the other two groups). This suggests that, similar to Indians in Canada and in the United States, Maoris may also share some degree of structural disadvantages in their country (though perhaps not to the same degree as their two North American counterparts). Unlike the two North American groups, the leading killers for the Maori are infectious/parasitic diseases and respiratory and circulatory conditions; suicide, accidents and violence do not seem to constitute significant causes of death. This pattern of cause-specific mortality is consistent with the hypothesis that the social, economic and political conditions for the Maori may be better than those of Indians in Canada and in the United States.

As mentioned earlier, New Zealand's more equitable income distribution as compared with Canada and the United States, plus the Maori's relatively large share of New Zealand's population, the group's homogeneity in language and culture and its strong involvement in the political structure of New Zealand society, may have some bearing on their less disadvantaged mortality profile. Disentangling the causal processes for such effects remains an important task for further investigation.

Differences in the pattern of mortality between Canadian and American Indians need further examination. Why do Canadian Indians suffer greater disproportionate relative risks of premature death from suicide and homicide? Differential levels of poverty, social disorganization and substance abuse in these two populations may account for part of this phenomenon. Research that takes into account community and individual level effects on mortality may help to shed light on this question. Recently, it has been shown that at the individual level of analysis, life style factors such as substance abuse and poor health habits are important determinants of early death, while at the neighbourhood level, differential income and socioeconomic disadvantages correlate strongly with mortality discrepancies (Le Clere, Rogers & Peters, 1997; Rogers *et al.*, 1996). Finally, the cultural bases of observed mortality gaps across aboriginal populations should be carefully explored. In the long term, some cultural practices may promote good health and longevity, while others may be detrimental to population health (Jarvis & Northcott, 1987; Trovato, 1988; Young, 1994; Syme & Berkman, 1976).

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References

AGRESTI, A. (1990) *Categorical Data Analysis*. John Wiley and Sons, New York.

ANDERSSEN, E. (1998) Canada's squalid secret: life on native reserves. *The Globe and Mail* (October 12th), A1, A3.

BACHMAN, R. (1992) *Death and Violence on the Reservation: Homicide, Family Violence, and Suicide in American Indian Populations*. Auburn House, New York.

BIENVENUE, R. (1983) Comparative colonial systems: the case of Canadian Indians and Australian Aborigines. *Aust. Can. Stud.* **1**, 30–43.

BOBET, E. (1989) Indian mortality. In: *Canadian Social Trends*. Thompson Publishing, Toronto.

BOLDT, M. (1993) *Surviving as Indians*: *The Challenge of Self-Government*. University of Toronto Press, Toronto.

BROUDY, D. W. & MAY, P. A. (1983) Demographic and epidemiologic transitions among the Navajo Indians. *Social Biol.* **30**, 1–16.

CERCARELLI, L. R. (1994) Road crashes involving Aboriginal people in Western Australia. *Accid. Annal. Prev.* **26**(3), 361–369.

CLOGG, C. C. & ELIASON, S. R. (1987) Some common problems in log-linear analysis. *Sociol. Meths. Res.* **16**(1), 8–44.

DE WIT, M., EMBREE, B. & DE WIT, D. (1997) *Determinants of the Risk and Timing of Alcohol and Illicit Drug Use Onset among Natives and Non-Natives: Similarities and Differences*. Discussion Paper No. 97–2. Population Studies Centre, The University of Western Ontario, London, Ontario, Canada.

GLADMAN, D., HUNTER, E. M. M., MCDERMOTT, R. A., MERRIT, T. & TULIP, F. J. (1997) *Study of Injury in Five Cape York Communities*. Australian Institute of Health and Welfare, National Injury Surveillance Unit & Queensland Health.

GREY, A. (1990) *A Matter of Life and Death: Contemporary Aboriginal Mortality*. Aboriginal Studies Press, Canberra.

HEALTH CANADA (1995) *Mortality Data and Population Counts for the Registered Indians of Canada for 1979 to 1992*. Special Tabulation. Vital Statistics and Indian Health Data, Medical Services Branch, Ottawa, Ontario.

HEALTH CANADA (1996) *Trends in First Nations Mortality, 1979–1993*. Minister of Public Works and Government Services Canada (Cat. No. 34–79/1993E), Ottawa, Ontario.

HISNANICK, J. J. (1994) Comparative analysis of violent deaths in American Indians and Alaska Natives. *Social Biol.* **41**(1–2), 96–109.

HOGG, R. (1992) Indigenous mortality: placing Australian Aboriginal mortality within a broader context. *Social Sci. Med.* **35**(3), 335–346.

HOGG, R. & THOMSON, N. (1992) *Fertility and Mortality of Aborigines Living in the Qeensland Aboriginal Communities, 1972–1990*. Australian Institute of Health and Welfare, Aboriginal and Torres Strait Islander Health Series No. 8, Australian Government Publishing Service, Canberra.

Honari, M. (1990) Causes of Aboriginal mortality. In: *A Matter of Life and Death: Contemporary Aboriginal Mortality*, pp. 139–146. Edited by Alan Grey. Aboriginal Studies Press, Canberra.

Jaffe, A. J. (1992) *The First Immigrants from Asia: A Population History of the North American Indians*. Plenum Press, New York.

Jarvis, G. K. & Boldt, M. (1982) Death styles among Canada's Indians. *Social Sci. Med.* **16**, 1345–1352.

Jarvis, G. K. & Northcott, H. (1987) Religion and differences in morbidity and mortality. *Social Sci. Med.* **25**(7), 813–824.

Kunitz, S. J. (1983) *Disease Change and the Role of Medicine: The Navajo Experience*. University of California Press, Berkeley, CA.

Kunitz, S. J. (1990) Public policy and mortality among indigenous populations. *Popul. Dev. Rev.* **16**(4), 647–672.

Kunitz, S. J. (1994) *Disease and Diversity: The European Impact on the Health of Non-Europeans*. Oxford University Press, New York.

Laird, N. & Olivier, D. (1981) Covariance analysis of censored survival data using log-linear analysis techniques. *J. Am. statist. Assoc.* **76**(374), 231–240.

Larson, M. G. (1984) Covariate analysis of competing-risk data with log-linear models. *Biometrics* **40**, 459–469.

Le Clere, F. B., Rogers, G. R. & Peters, K. D. (1997) Ethnicity and mortality in the United States: individual and community correlates. *Soc. Forces* **76**(1), 169–198.

Levy, J. E. & Kunitz, S. J. (1971) Indian reservations, anomie and social pathologies. *SWest. J. Anthrop.* **27**(2), 97–128.

Lieberson, S. (1961) A societal theory of race relations. *Am. Soc. Rev.* **26**(6), 902–910.

Livi-Bacci, M. (1992) *A Concise History of Human World Population*. (Translated by Carl Ipsen.) Blackwell, Cambridge, MA.

Mao, Y., Moloughney, B., Semenciw, R. M. & Morrison, H. I. (1992) Indian reserve and registered Indian mortality in Canada. *Can. J. publ. Hlth* **83**(5), 350–353.

Mao, Y., Morrison, H. I., Semenciw, R. M. & Wigle, D. T. (1986) Mortality on Canadian Indian reserves 1977–1982. *Can. J. publ. Hlth* **77**, 263–268.

Moore, D. (1992) Beyond the bottle: introducing anthropological debate to research into Aboriginal alcohol use. *Aust. J. Soc. Issues* **27**(3), 173–193.

Morrison, H. I., Semenciw, R. M., Mao, Y. & Wigle, D. T. (1986) Infant mortality on Canadian Indian reserves, 1976–1983. *Can. J. publ. Hlth* **77**, 269–273.

Nagel, J. (1995) American Indian ethnic renewal: politics and the resurgence of identity. *Am. Soc. Rev.* **60**, 947–965.

New Zealand Department of Statistics (1995) *Mortality Data and Population Counts for New Zealand Maoris and Non-Maoris for 1980–82 and 1990–92*. Special Tabulation, Christchurch, NZ.

Ng, E. (1996) Disability among Canada's Aboriginal peoples in 1991. *Hlth Rep.* **8**(1), 25–32.

Norris, M. J. (1996) Contemporary demography of Aboriginal peoples in Canada. In: *Visions of the Heart: Canadian Aboriginal Issues*, pp. 179–237. Edited by D. Long & O. P. Dichason. Harcourt Brace, Toronto, Canada.

Olshansky, S. J. & Ault, A. B. (1986) The fourth stage of epidemiologic transition: the age of delayed degenerative diseases. *Milbank meml Fund q. Bull.* **46**(3), 355–391.

Omran, A. (1971) The epidemiological transition: a theory of epidemiology of population change. *Milbank meml Fund q. Bull.* **49**, 509–538.

Pool, I. (1991) *Te Iwi Maori: A New Zealand Population Past, Present and Projected*. Aukland University Press, Auckland, NZ.

Pool, I. (1994) Cross-comparative perspectives on New Zealand's health. In: *Social Dimensions of Health and Disease: New Zealand Perspectives*, pp. 16–49. Edited by J. Spicer, A. Trlin & J. A. Walton. Dunmore Press, Palmerston North.

Population Reference Bureau (1999) *World Population Data Sheet, 1999*. Washington, DC.

Rogers, R. G. & Hackenberg, R. (1987) Extending epidemiologic transition theory: a new stage. *Social Biol*. **34**(3–4), 234–243.

Rogers, R. G., Hummer, R. A., Nam, C. & Peters, K. (1996) Demographic, socioeconomic, and behavioral factors affecting ethnic mortality by cause. *Soc. Forces* **74**, 1419–1438.

Romaniuc, A. (1981) Increase in natural fertility during the earlier stages of modernization: Canadian Indian case study. *Demography* **17**(2),157–172.

Romaniuc, A. (1987) Transition from traditional high to modern low fertility: Canadian Aboriginals. *Can. Stud. Popul*. **14**(1), 69–88.

Romaniuc, A. (1995) Canada's aboriginal peoples: population growth under conditions of encounter of civilizations – a historical perspective. In: *Proceedings of the 1995 Symposium Organized by the Federation of Canadian Demographers*, Ottawa, Ontario, October 23rd to 25th, pp. 239–250.

Rosenwaike, I. (1992) *Mortality Experience of Hispanic Populations*. Greenwood Press, Westport, CT.

Royal Commission on Aboriginal Peoples (1993) *Overview of the Second Round*. Minister of Supply and Services Canada, Ottawa.

Royal Commission on Aboriginal Peoples (1994) *Toward Reconciliation: Overview of the Fourth Round*. Minister of Supply and Services Canada, Ottawa.

Royal Commission on Aboriginal Peoples (1995) *Choosing Life: Special Report on Suicide Among Aboriginal People*. Minister of Supply and Services Canada, Ottawa.

Simpson, G. E. & Yinger, M. J. (1985) *Racial and Cultural Minorities: An Analysis of Prejudice and Discrimination*. Harper and Row, New York.

Smith, A. H. (1984) Determinants of differences in mortality between New Zealand Maoris and non-Maoris aged 15–64. *N. Z. med. J*. **97**(749), 101–108.

Statistics Canada (1995) *Projections of Population with Aboriginal Ancestry, Canada, Provinces/Regions and Territories, 1991–2016*. Minister of Industry (Catalogue No. 91–5390XPE), Housing and Social Statistics Division, Ottawa, Ontario.

Statistics Canada (1996) *Population and Mortality by Cause of Death, Age and Sex, 1981 and 1991*. Special Tabulations. Ottawa, Ontario.

Syme, S. L. & Berkman, L. F. (1976) Social class, susceptibility and sickness. *Am. J. Epidemiol*. **104**(1), 1–8.

Taylor, J. (1997) The contemporary demography of indigenous Australians. *J. Aust. Popul. Ass*. **14**(1), 77–114.

Thornton, R. (1981) Demographic antecedents of a revitalization movement: population change, population size, and the 1890 Ghost Dance. *Am. Soc. Rev*. **46**, 88–96.

Thornton, R. (1987) *American Indian: Holocaust and Survival: A Population History Since 1492*. University of Oklahoma Press, Norman, OK.

Trovato, F. (1987) A macrosociological analysis of Native Indian fertility in Canada: 1961, 1971, and 1981. *Soc. Forces* **66**(2), 463–485.

Trovato, F. (1988) Mortality differentials in Canada, 1951–1971: French, British and Indians. *Cult. Med. Psych*. **12**, 219–237.

United States Department of Health and Human Services (1995) *Mortality Data and Population Counts for American and Alaskan Indians for 1972–74 and 1989–91*. Special Tabulation. Indian Health Service, Rockville, MD.

United States Department of Health and Human Services, Indian Health Service (1994) *Trends in Indian Health, 1994*. Rockville, MD.

Waldram, J. B., Herring, D. A. & Young, T. K. (1995) *Aboriginal Health in Canada: Historical, Cultural, and Epidemiological Perspectives*. University of Toronto Press, Toronto.

Whitehead, P. C. & Hayes, M. J. (1998) *The Insanity of Alcohol: Social Problems in Canadian First Nations Communities*. Canadian Scholars' Press Inc, Toronto.

Williams, D. R. & Collins, C. (1995) US socioeconomic and racial differences in health: patterns and explanations. *Ann. Rev. Sociol*. **21**, 349–386.

World Health Organization (1996) *Computerized Annual Mortality Statistics by Age, Sex, Cause of Death and Country, along with Population Counts for around 1980 and 1990.* Geneva, Switzerland.

Young, K. T. (1994) *The Health of Native Americans: Towards a Biocultural Epidemiology*. Oxford University Press, New York.

Young, T. K. (1983) Mortality pattern of isolated Indians in Northwestern Ontario: a 10-year review. *Publ. Hlth Rep*. **98**(5), 467–475.

Young, T. K. (1988a) Are subartic Indians undergoing the epidemiologic transition? *Social Sci. Med*. **26**, 659–671.

Young, T. K. (1988b) *Health Care and Cultural Change: The Indian Experience in the Central Subarctic*. University of Toronto Press, Toronto.

Young, T. K., Bruce, L., Elias, J., O'Neil, D. & Yassie, A. (1991) *The Health Effects of Housing and Community Infrastructure on Canadian Indian Reserves.* Indian and Northern Affairs Canada, Ottawa, Ontario.

Zodgekar, A. V. (1979) Mortality. In: *The Population of New Zealand: Interdisciplinary Perspectives*, pp. 89–111. Edited by R. J. W. Neville & C. J. O'Neill. Longman Paul, Aukland, NZ.