Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Mortality Projections of Registered Indians, 1982 to 1996

Canada

MORTALITY PROJECTIONS OF REGISTERED INDIANS, 1982 TO 1996

by

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for
Research Branch
Corporate Policy

INDIAN AND NORTHERN AFFAIRS CANADA

April 1985

©Published under the authority of the
Hon. David E. Crombie, P.C., M.P.,
Minister of Indian Affairs and
Northern Development,
Ottawa, 1985.

QS-3386-000-EE-A1

Cette publication peut aussi être obtenue
en français sous le titre:

Projections de la mortalité des Indiens
inscrits, 1982-1996

This publication is one of four reports on the documentation of population projections of registered Indians, 1982 to 1996. The other three reports are:

- Population Projections of Registered Indians, 1982 to 1996
- Fertility Projections of Registered Indians, 1982 to 1996
- Migration Projections of Registered Indians, 1982 to 1996

ACKNOWLEDGEMENTS

This report is one of the background studies of the project, Population Projections of Registered Indians, 1982 to 1996. The project was initiated by the Research Branch, Indian and Northern Affairs Canada (INAC) in response to departmental needs for up-to-date and accurate population projections and was undertaken by Statistics Canada. It was carried out by the population projection staff of the Demography Division, Statistics Canada in consultation with S. Klein, project leader and G.Y. Larocque, Chief, Socio-demographic Research Section, Research Branch, INAC. Appreciation is expressed to L. Dell'Oso who provided research assistance with the cooperation of D. Laflamme and A. Bannerman. Programming assistance was provided by V. Kawka. Appreciation is also expressed to M.V. George, J. Perreault of the Demography Division and G.Y. Larocque, S. Klein and P. Gauvin of the Research Branch, INAC for their comments on earlier drafts of the paper. Thanks are also due to S. Paulin for typing.

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SUMMARY

The purpose of this report is to describe and document the development of mortality projections, for the population projections of registered Indians, 1982 to 1996. It covers the main aspects of data quality and adjustment, mortality trends, life table estimation, projection assumptions and results.

The report begins with a discussion of the quality and limitations of INAC Register data which form the basis for developing mortality projections. The quality of data represents one of the principal concerns for the development of mortality assumptions and the analysis of mortality trends among registered Indians. This concern has two aspects:

1) that the INAC Register is maintained for administrative rather than statistical purposes, and as such may not provide an ideal basis for estimates of mortality; and,

2) that the Indian population is a relatively small one and as such, care must be taken in evaluating mortality trends and patterns based on it.

The aspects of this concern with data quality have been addressed by:

1) As complete a correction for statistical data deficiencies as was possible, involving:

   a) corrections of annual data for late reporting of births and deaths with corresponding adjustments to population estimates for the years 1971-81; and,

   b) adjustments to infant death and birth data for underreporting arising from those events in which a death occurred before the birth had been reported resulting in neither birth nor death being recorded in the Register.

2) The use of aggregated death rates in the examination of mortality trends and regional mortality differentials, in order to avoid rates for which the population base is too small to permit a meaningfull comparison.

Trends in Indian mortality are analyzed and compared with those for the Canadian population at the Canada level. The analysis indicated a gradual decline in Indian mortality over the 1971-81 period, for most ages, but a

rapid decline for infants. However, these trends must be interpreted with caution since effects of underreporting are not incorporated into the time series data and, the data appear to have become progressively poorer in recent years. This is especially true in the case of infant mortality.

A relational model employing life table data for the total Canadian population is used to produce life table estimates for the Indian population for 1976 and 1981. These estimates are considerably below the Canada average for the corresponding time periods. In 1981, male and female life expectancies at birth for the Indian population are estimated to be 62 and 69 years respectively compared to corresponding averages of 72 and 79 years for Canadians in general. Indian life expectancies at birth are on a par with the levels reached about 30 to 40 years ago by the total Canadian population.

For purposes of providing a range of projected deaths, two assumptions of mortality were offered:

1) Constant mortality: under this assumption the same set of survival rates from the 1981 registered Indian life table is used throughout the projection period.

2) Decreasing mortality: under this assumption, life expectancy for Indian males and females would increase and reach 68 and 75 years respectively by 1996.

The report concludes with a brief evaluation of the projection results.

1. INTRODUCTION

Mortality projections of registered Indians (hereinafter called Indians) entail the development of a set of annual survival rates. These survival rates were derived from life tables which were constructed for the Indian population, based on data from the Indian Register of Indian and Northern Affairs Canada (INAC).

This paper describes the method of projection, the assumptions and the major aspects involved in the development of life tables. It consists of 4 main sections: the first section deals with the evaluation and adjustments of the INAC Register data; the second presents mortality trends; the third discusses the method used for life table construction; and, finally, the fourth presents the mortality assumptions and evaluation of the results.

2. DATA SOURCE

There are two major sources of data on the mortality of Indians in Canada: annual files of the Medical Services Branch, Health and Welfare Canada and the Indian Register, Indian and Northern Affairs Canada (INAC).

Data from Health and Welfare Canada were not directly used for purposes of developing mortality projections of the Indian population due to a number of limitations. The data coverage and collection methods vary by province: for the Atlantic and Ontario regions, data on deaths are reported for the on-reserve population only, while in Quebec, data are collected for only some reserves. In Manitoba and Saskatchewan, births and deaths are tabulated through the Provincial Health Insurance Department which indicate registered Indian status. In Alberta, however, Indians must register with the Medical Services Branch, which is similar to the current system in the Pacific[1] region. In other provinces and the Northwest Territories, death data are obtained from reports of nurses working on the reserves or settlements.

Unlike the death data reported by INAC, the data from Health and Welfare Canada also include deaths by cause, as well as by age and sex. However, these data are not directly used for projections for the reasons cited above

(1) The Pacific region of Health and Welfare Canada corresponds to the INAC region of British Columbia.

although they do provide some additional information on the Indian mortality experience.

Indian mortality data used in this study were obtained from INAC's Indian Register. The Register's reporting system provides data on annual births, deaths and population counts by age and sex from 1966 on. While some data exist for the earlier periods they were not computerized until 1966. The registration of both births and deaths suffers from problems of late reporting and underreporting. Effects of late reporting on vital rates have been discussed in other studies on Canadian Indians (see Piché and George, 1973; Romaniuk and Piché, 1972).

2.1 **Data Quality**

For purposes of analysing trends in death rates and constructing life tables, the quality of the Indian Register data poses problems because of late and underreporting of deaths and births. A description of the extent of late and underreporting and their adjustment follows.

2.1.1 **Late Reporting and Its Adjustment**

Late reporting of births and deaths may seriously affect data quality. A measure of the delay observed in reporting events is obtained from INAC data on the classification of births and deaths by year of reporting and year of occurrence. Delays in the reporting of known events are, on average, longer for births than deaths. Reporting of births has occurred eleven years and more

after the event. In contrast, most (98%) of the known deaths are reported within three years. Therefore, the adjustment of death data for late reporting is based on a shorter lag period.

Data on births and deaths were adjusted for late reporting for the years 1971-1981, based on the classification of events by year of reporting and year of occurrence. In the adjustment of data for late reporting, there are two categories of events to be considered: (i) those which have been registered and classified by year of occurrence and year of reporting; and (ii) those which have probably occurred but have not yet been reported. The events in the latter category are estimated from an analysis of late reporting patterns as indicated by the cross-classification of events by year of occurrence and year of reporting. In the case of death registration, late reporting usually occurs up to 2 years after the death. On this basis, the only year which required an estimate of the number of deaths which probably had occurred but were not yet reported was 1981, since the most recent year for which deaths were reported by year of occurrence was 1982 (at the time of this study). The 1982 data indicated the number of deaths which had occurred in 1981 but were not reported until 1982. Therefore it was necessary to estimate the number of deaths which probably had occurred in 1981 but would be reported only by 1983.

The adjustment of death data can be summarized as follows.

(1) reallocating the late reported deaths already registered by year of occurrence using the cross-classification of deaths by year of occurrence and year of reporting,

(2) estimating the not-yet reported deaths and adding them to the appropriate year(s) of occurrence, in this case, 1981.

The adjustment of data for late reporting is presented for total and infant deaths in Tables 1 and 2 respectively. The adjustment for late reporting of deaths in general ranges from 30% to 50% for the years 1971-1981. In comparison, the adjustment for late reporting of births, tends to be greater, ranging from 45% to 92%. Adjustment of birth data is presented in Tables 2 to 5 of the report on fertility projections (Ram, B. and Romaniuc, A., 1985). Annual corrections for late reporting over the 1971-81 period are greatest for births, averaging 70%, and least for total deaths, with an average adjustment of 40%. Compared to total deaths, the extent of adjustment for late reporting is greater for infant deaths, ranging from corrections of 44% to 99%, and suggests that the volume of late reporting for infant deaths is more similar to that of births than total deaths. On average, though, the extent of late reporting for infant deaths is about 65%, less than

Table 1. Adjustment of Registered Indian Deaths for Late Reporting, Canada, 1971-1981

Year	Deaths reported but not necessarily occurring during year	Deaths reported in year of occurrence(1)	Deaths late reported, i.e. not reported in year of occurence	Adjusted number of deaths occurring during year	Adjustment for late reporting %
	(1)	(2)	(3)	(4)=(2)+(3)	(5)=(3)/(2)X100
1971	2,062	... (2)	... (2)	2,563(2)	...
1972	2,049	...	...	2,132(2)	...
1973	2,184	1,658	555	2,213	33.47
1974	2,215	1,649	595	2,244	36.08
1975	2,041	1,499	697	2,196	46.50
1976	2,286	1,612	588	2,200	36.48
1977	2,347	1,697	523	2,220	30.82
1978	2,126	1,635	629	2,264	38.47
1979	2,078	1,480	592	2,072	40.00
1980	2,061	1,427	671	2,098	47.02
1981	1,993	1,397	700	2,097	50.11

(1) The number of deaths reported in the year of occurrence is a subset of the total number of deaths reported in the year, in column (1).
(2) For years 1971 and 1972, cross-tabulation of deaths by year of occurrence and year of reporting was not available. Therefore the total number of deaths was estimated by a different method for these years.
... Not applicable.
Source: Columns 1 & 2 - Indian Register data;
Column 3 - 1973-80: Indian Register data; and
1981: Estimated by Projections Section, Demography Division Statistics Canada.

Table 2. Adjustment of Registered Indian Infant Deaths for Late Reporting, Canada, 1971-1981

Year	Infant deaths reported but not necessarily occurring during year	Infant deaths reported in year of occurrence(1)	Infant deaths late reported, i.e. not reported in year of occurrence	Adjusted number of infant deaths occurring during year	Adjustment for late reporting %
	(1)	(2)	(3)	(4)=(2)+(3)	(5)=(3)/(2)X100
1971	336	... (2)	... (2)	423 (2)	...
1972	341	...	...	348 (2)	...
1973	288	189	105	294	55.56
1974	269	159	117	276	73.58
1975	279	169	97	266	57.40
1976	237	132	80	212	60.61
1977	244	158	70	228	44.30
1978	170	107	59	166	55.14
1979	161	102	59	161	57.84
1980	142	78	77	155	98.72
1981	156	88	73	161	82.95

(1) The number of infant deaths reported in the year of occurrence is a subset of the total number of infant deaths reported in the year, in column (1).
(2) For years 1971 and 1972, cross-tabulation of deaths by year of occurrence and year of reporting was not available. Therefore the total number of infant deaths was estimated by a different method for these years.
...Not applicable.
Source: Same as Table 1.

that of births. For all three vital events, similar reductions in percentage corrections have taken place in 1977, followed by an almost steady increase in the adjustments for later years. Reasons for the reduction in adjustments for late reporting in 1977 are not known.

2.1.2 **Underreporting of Infant Deaths and Its Adjustment**

An analysis of the adjusted time series of total and infant death rates, provided in Section 3, indicated that the quality of data on deaths still remained suspect even after adjustment for late reporting, especially for infant deaths.

Problems associated with underreporting of births are dealt with in detail in the report on fertility projections (Ram, B. and Romaniuc, A., 1985). These problems also have an impact on mortality, but in a less direct way. In particular, underreporting of births has an impact on mortality only to the extent that failure to report a birth occurs in conjunction with the infant's death. The adjustment for underreporting of infant deaths based on that of births is applicable in cases in which a death occurred before the birth had been reported resulting in neither birth nor death being recorded in the Register.

It is highly probable that those infants whose births were not registered in the year of occurence and who subsequently died, were never registered. The likelihood of births followed by infant deaths not being reported is high for two reasons: only about half of the known births are

reported within the year of occurrence; and, for administration purposes, it is unnecessary to add and immediately delete an individual in the Register.

The approach used in the correction of underreporting of infant deaths is identical to the reverse-survival technique described in the fertility report for births. This technique estimates births from the reported population size in age groups 0-4 or 5-9, with assumptions about the mortality experienced by those groups. From this estimate, the total number of underreported births are derived. The estimates obtained here of underreported births, with infant death subsequently taking place, represent a subset of the total number of underreported births.

In the absence of other information, the reverse-survival technique was applied utilizing a preliminary Indian life table based on unadjusted Indian Register data. The resulting annual estimates of unreported births followed by infant deaths for two selected time periods are presented in Table 3. Because the data used for the construction of the preliminary life tables were not adjusted for late reporting and underreporting, the estimates in Table 3 can be considered low.

Table 3. Average Annual Number of Unreported Births Followed by Infant Deaths

Period	Male	Female	Total
1972-76	31	29	60
1977-81	29	27	56

Source: Projections Section, Demography Division, Statistics Canada.

On average, these estimates implied that the infant mortality rates for the 1972-76 period were higher by a factor of 21.6%. The estimates of underreporting for 1972-1976 were incorporated into the life tables developed from the 1972-76 aggregated death rates. Estimates of underreporting for the 1977-81 period were not utilized since Indian death data for this period were not used in the construction of life tables (see Section 4.2).

3. MORTALITY TRENDS

Annual crude and age-sex specific death rates are available for the provinces and Canada, from 1971-81. The time series data have been adjusted only for late reporting of births and deaths by age and sex but not for the estimated underreporting of births and infant deaths discussed in Section 2.1.2. Because these time series data do not incorporate adjustments for underreporting, the trends suggested by an analysis of their annual rates must be treated with caution. Also, at the provincial level especially, the rates are sometimes based on such small numbers that trends become erratic. At both national and provincial levels a two-year average of deaths was used in calculating rates because of the small numbers.

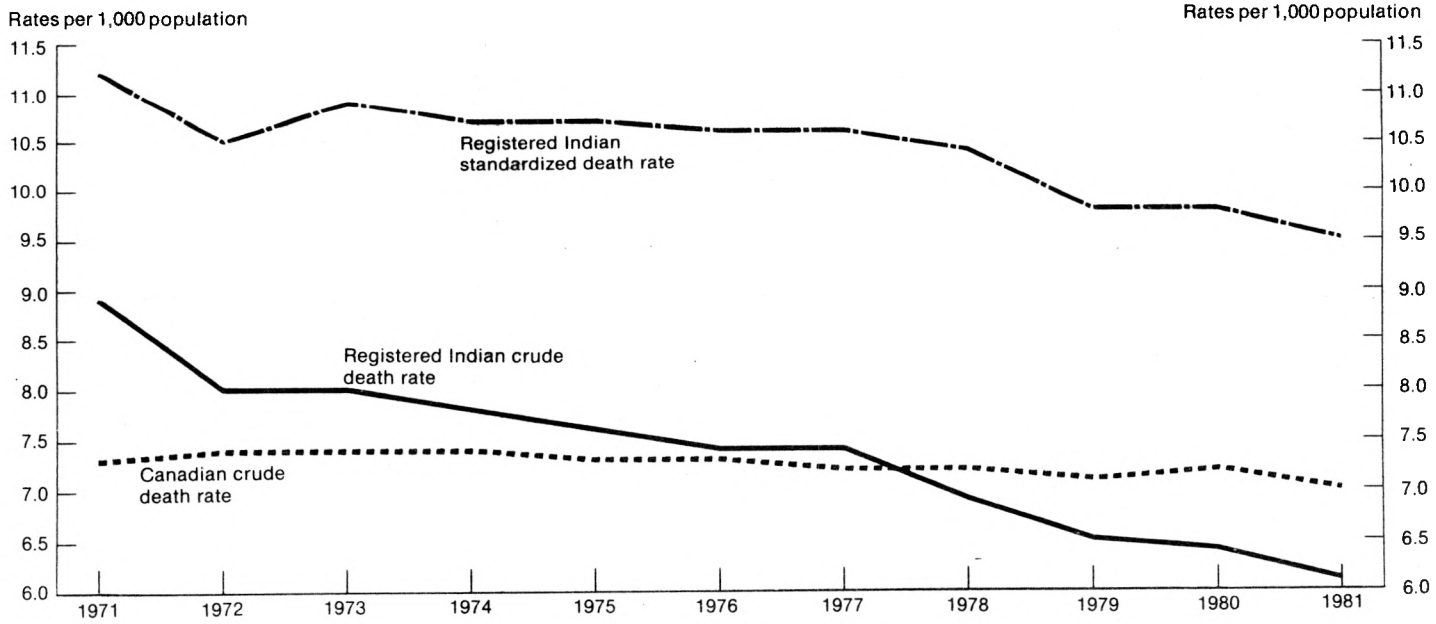
With these limitations in mind, trends of Indian death rates are analysed and compared with those for the Canadian population in general.

3.1 Canada Level

The total Indian population has shown an overall decline in mortality, from 8.9 deaths per thousand population in 1971 to 6.1 per thousand by 1981. Crude death rates for the Canadian population in general decreased slightly, from about 7.4 to 7.0, during the same period. In order to compare rates between the two populations, differences in their age structures must be controlled for, since the Indian population has a younger age structure than that of Canadians in general. Indian crude death rates

are standardized by using the Canadian age-sex structure of the corresponding year as standard. The difference between the standardized rates of Indians and crude rates of total Canadians widens considerably, with standardized Indian rates remaining at a level much higher than those of the total Canadian population (see Figure 1). The standardized Indian death rate was 11.2 deaths per thousand population in 1971 which declined to 9.5 by 1981. The 15% decrease in standardized death rates over the 1971-81 period is less than the decline of 31% observed in the crude death rates of the Indian population.

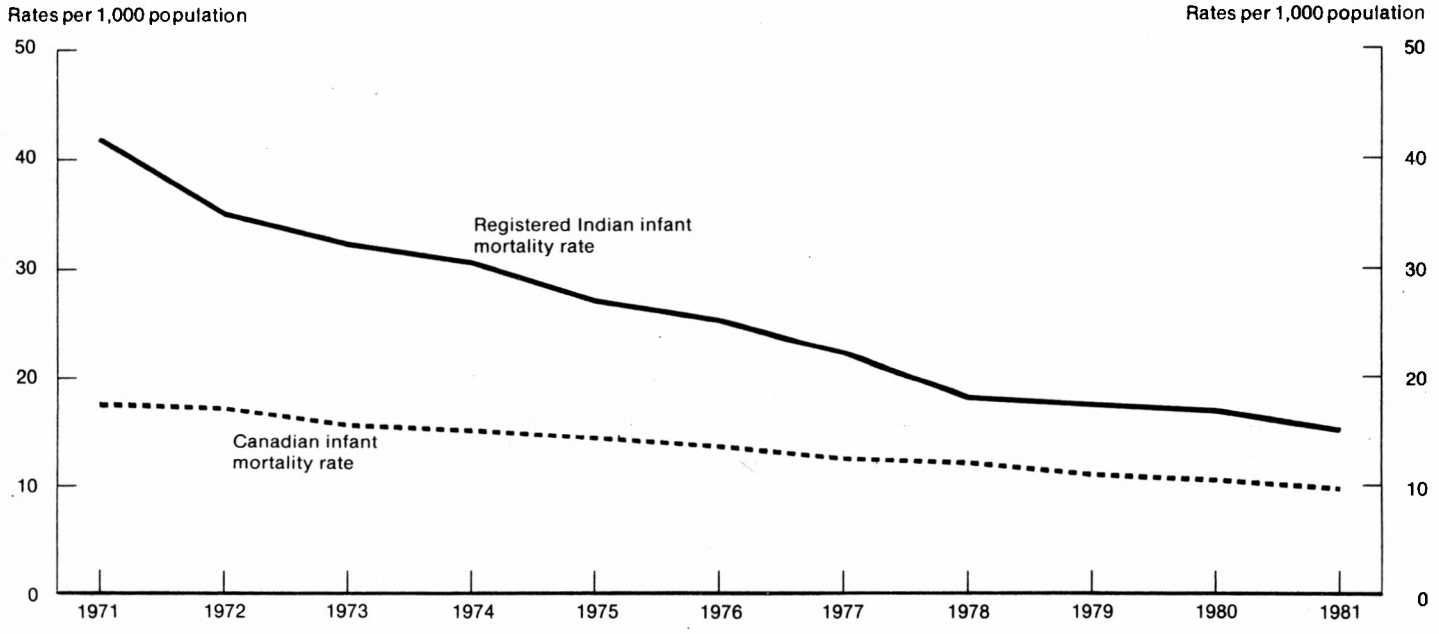
Figure 1
Crude and Standardized(1) Death Rates of the Registered Indian Population and Crude Death Rates of the Total Canadian Population, Canada, 1971-81



(1) Indian crude death rates have been standardized using the age-sex structure of the total Canadian population.
Source: Registered Indian death rates based on Indian Register data adjusted for late reporting of births and deaths by Projections Section, Demography Division, Statistics Canada.
Death rates for total Canadian population from Statistics Canada, Vital Statistics Catalogue Nos. 84-204 and 84-206.

Infant mortality rates (infant deaths per 1,000 live births) declined rapidly during the 1971-81 period from 42 to 15, a decrease of about 64%. In comparison, corresponding Canadian infant mortality rates decreased gradually from 17.5 in 1971 to 9.6 in 1981 (see Figure 2). These data suggest that the Indian infant mortality rates are rapidly converging to Canadian levels, but these data should be treated with caution since they reflect adjustments only for late reporting. Also, comparison

Figure 2
Infant Mortality Rates of Registered Indian and Total Canadian Populations, Canada, 1971-81



Source: Registered Indian mortality rates based on Indian Register data adjusted for late reporting of births and deaths by Projections Section, Demography Division, Statistics Canada.
Mortality rates for total Canadian population from Statistics Canada, Vital Statistics Catalogue Nos. 84-204 and 84-206.

Table 4. Infant Mortality Rates of Registered Indian and Total Canadian Populations, Canada, 1971-1981

Year	Registered Indian		Total Canadian
	INAC Adjusted	Medical(1) Services Branch	Vital Statistics
1971	41.8	45.2	17.5
1972	35.0	47.5	17.1
1973	32.2	40.8	15.5
1974	30.5	39.3	15.0
1975	27.0	38.6	14.3
1976	25.2	32.1	13.5
1977	22.2	33.5	12.4
1978	18.1	26.5	12.0
1979	17.4	28.2	10.9
1980	16.8	24.4	10.4
1981	15.0	21.8	9.6

(1) See Section 2 for description of data from Health and Welfare Canada.

Source: INAC rates based on Indian Register data adjusted for late reporting of births and deaths.
Medical Services Branch Annual Reports, 1971-81, Health & Welfare Canada.
Death rates for total Canadian population, Statistics Canada, Vital Statistics Catalogue Nos. 84-204 and 84-206.

with alternative data sources from Health and Welfare Canada, indicates higher rates for the same period (see Table 4). For example, the infant mortality rate based on Health and Welfare Canada data in 1976 was about 32 compared to an adjusted 25 from the Register. Corresponding figures for 1981 from Health and Welfare Canada indicate an infant mortality rate of 22 per thousand compared to an adjusted 15 per thousand from the Register. These discrepancies between the two data sources provide some evidence of underreporting of infant deaths in the

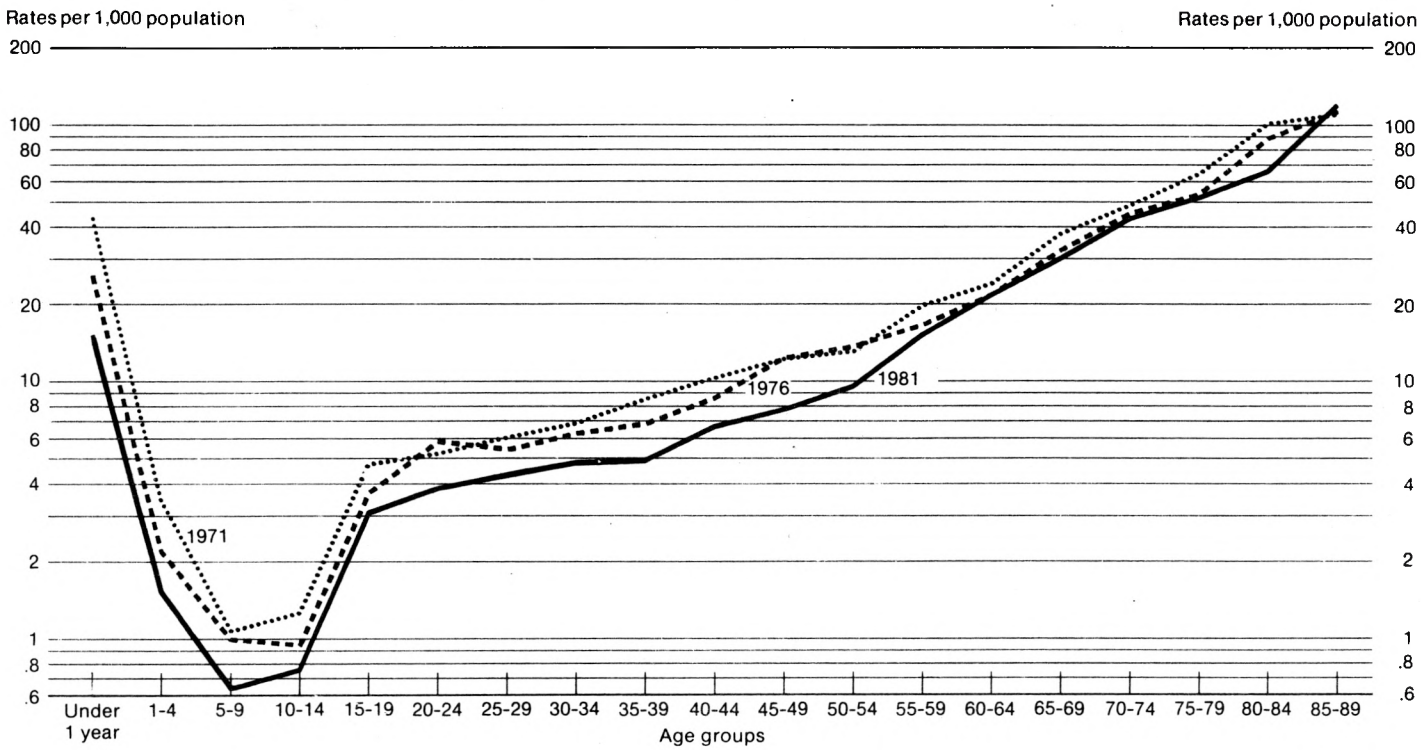
Register, although the two sets of rates are not strictly comparable since the populations represented differ to some extent.

Age-specific death rates of the Indian population adjusted for late reporting, are plotted for selected years, 1971, 1976 and 1981 in Figure 3. Most ages have experienced a decline in mortality over time, with the greatest decrease occurring among infants. However, the age-specific decline in mortality has not been uniform in all age groups and time periods. For example, the 20-24 age group showed a slight increase in mortality between 1971 and 1976. For the same period little if any decrease was observed in the 45-54 age groups. In the 1976-81 period, the decrease in death rates for the age groups 60-79 was slight compared to that for the earlier 1971-76 period. In general, though, the adjusted rates show an overall decline for the 1971-81 period for all ages.

Comparison of 1981 age-sex specific death rates between the Indian and total Canadian populations show that for both sexes Indian death rates are higher at most ages with the exception of older ages when a crossover in mortality occurs (Figure 4). Male and female Indian death rates become and remain lower than those of Canadians for the age groups, 70-74 and 75-79 respectively. This crossover may be a function of poor data quality since problems of underreporting of deaths are more likely to occur at the extremes of infant and old ages. But there

Figure 3

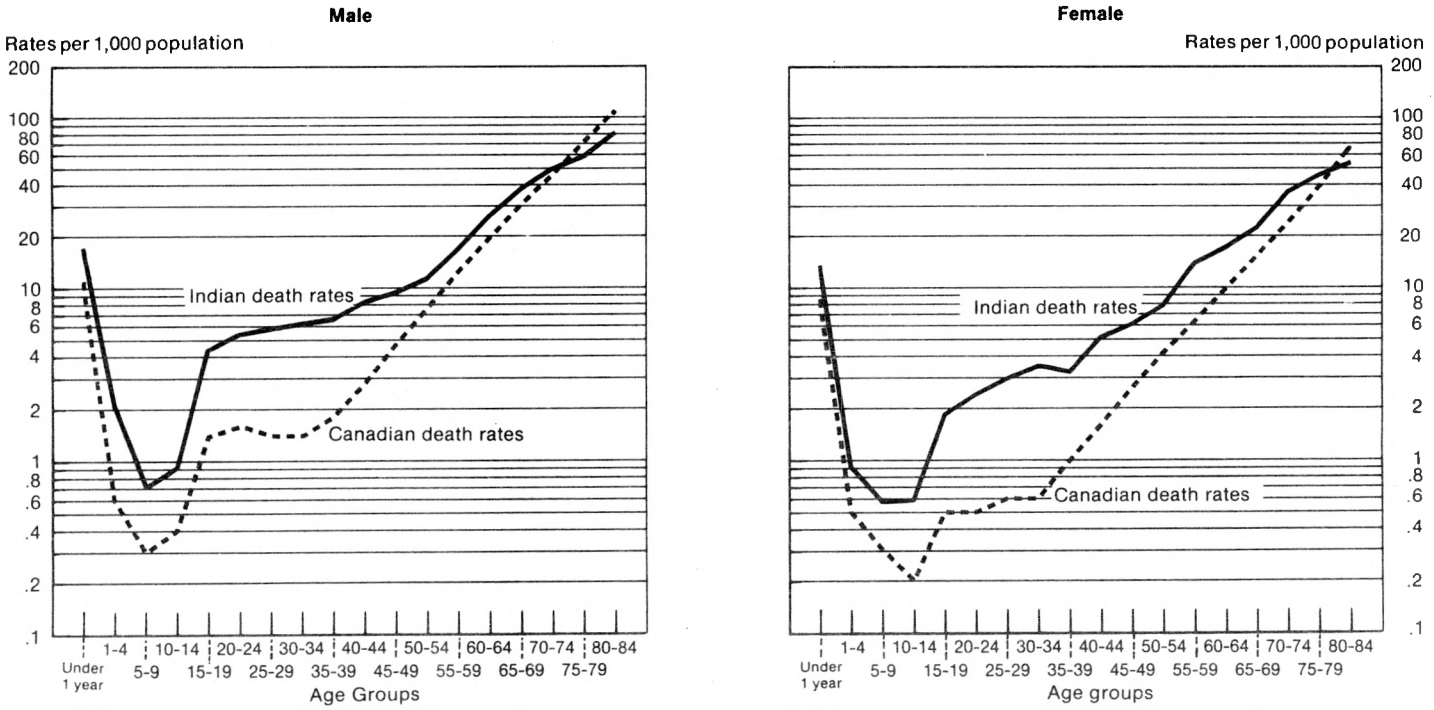
Age-specific Death Rates of the Registered Indian Population, Canada, 1971, 1976, 1981



Source: Registered Indian death rates based on Indian Register data adjusted for late reporting of births and deaths by Projections Section, Demography Division, Statistics Canada.

Figure 4

Age-Sex Specific Death Rates of Registered Indian and Total Canadian Populations, Canada, 1981



Source: Registered Indian death rates based on Indian Register data adjusted for late reporting of births and deaths by Projections Section, Demography Division, Statistics Canada.

Death rates for total Canadian population from Statistics Canada, Vital Statistics, Volume 1, Births and Deaths, Catalogue No. 84-204, 1981, Table 19.

is also a possibility that this crossover is real as suggested by Trovato (1984) in examining mortality differences of French, British and Native Indian groups in Canada. An explanation offered for its occurrence among natives is that of selectivity, i.e. that those members of a deprived minority who are able to survive through the high mortality years of infancy, youth and young adulthood probably would experience lower mortality at older ages than the population in general. However, given the quality of Indian mortality data it is difficult to conclude whether this 'crossover' effect is real or merely a function of underreporting.

The analysis of Indian age-specific death rates, over the 1971-81 period, indicates a gradual decrease in mortality rates for most ages, but a rapid decline for infants. But, as previously indicated, these trends must be interpreted with caution, since effects of underreporting are not incorporated into these adjusted time series.

3.2 **Regional Level**

A brief discussion of regional annual rates is provided here in order to highlight the problems of data quality and the subsequent approach used in life table estimation. It is difficult to analyse interprovincial differences in mortality rates given the effects of varying data quality by province and of small numbers. The numbers of total annual deaths are extremely small for

the Atlantic provinces and two territories as indicated in Table D1 of Appendix D. For each of these areas the number of annual deaths is less than 62. For purposes of analysing rates the Atlantic provinces have been grouped to form a region, the Yukon and Northwest Territories to form another.

An examination of crude death rates by region for 1971-81, given in Table D2 of Appendix D, reveals some year to year fluctuation in rates. Most of the regions show an overall decline in crude death rates with the exception of Alberta and the Territories in which fluctuations make it difficult to determine an overall trend. There is also variation amongst regions in Indian crude death rates. For example, in 1981 regional rates range from 5.2 to 7.9 while the total Indian rate is 6.1.

An examination of infant death rates (infant deaths per 1,000 population under age 1) in Table D3 also shows year to year fluctuations with some notable changes. For example, in the Atlantic region, the infant death rate drops from 13 to 3.2 between 1975 and 1976, and in the Territories from 29 to 12 between 1979 and 1980. Such effects can be attributed to extremely small numbers, and problems of data quality. The regions in general show an overall decline in infant death rates but there is a large range in regional rates. The eastern regions, Atlantic, Quebec and Ontario, have lower infant death rates than those of the west. In 1981 eastern rates range from 5.4 to

7.9, while western rates range from a low of 8.7 (Territories) to a high of 28.6. At the national level the 1981 Indian rate is 15 compared to about 10 for the total Canadian population. The extremely low infant death rates of the three eastern regions, especially during the 1978-81 period, do not seem plausible when compared to higher levels for the total Canadian population. This comparison indicates the problems of data quality and again suggests that some significant underreporting of infant deaths is occurring especially in the eastern regions. Reasons for the deterioration in the quality of death data in the recent years are not known.

4. LIFE TABLE ESTIMATION

The projection of Indian mortality requires the estimation of life tables to provide survival rates and measures of life expectancy. There are no known recent life tables for the Indian population, although some earlier ones had been constructed (see Section 4.3). Therefore, the present life tables were developed.

4.1 Some Considerations of Life Table Construction

Population size and variability in mortality were major considerations in the construction of life tables for the Indian population. The following provides the rationale for the construction of life tables based on aggregated death rates.

4.1.1 Consequences of Population Size for Life Table Construction

Estimates of mortality rates for small populations have an intrinsic limit to their accuracy. This limit is the number of significant digits in the rate, which may be determined by the number of leading zeros in the ratio 1.0/Population. In effect, this ratio represents the minimum difference that can be observed in a population's rates (e.g. from year to year) since the minimum difference in the number of deaths is 1.0.

Life tables representing a population's mortality are constructed by estimating the chances of survival from

birth to succeeding ages, based on observed mortality in intermediate ages. As a consequence, the accuracy of a life table depends on the accuracy of the infant mortality rate(2). Life tables are generally calculated as if they represented the experience of a cohort numbering 100,000 at birth. Consequently, life tables tend to require mortality rates that have, at least, 5 significant digits. The Indian population has about 4,500 births of each sex annually, at the national level. Consequently, its infant mortality rate can have no more than 3 significant digits or only the first 3 digits in the mortality rate are meaningful. This suggests that the level of accuracy that is possible in a life table of the Indian population differs from the level generally required by a factor of 100. Averages over 5-year periods must be employed to allow for these limitations. However, such averaging will not aid in the examination of mortality patterns for small geographic areas(3).

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(2) The number of significant digits in the estimate of chances of survival to, say, age 2 cannot be greater than the corresponding number in the estimate of mortality in the first year of life.

(3) For example, the construction of mortality rates aggregated over 5-year age groups and over time periods of 5 years, have 4 or fewer significant digits in most provincial age groups. That is, this degree of time aggregation may be adequate at the national level, but problems with small population size will still emerge with geographic disaggregation.

4.1.2 Short-term Variability in Mortality

In order to examine Indian mortality on a geographic basis, it becomes necessary to calculate mortality rates averaged over longer time periods. This is necessary, since, despite aggregation into five-year age groups, annual provincial populations are too small to provide stable estimates of the rates.(4)

Rates that have been averaged over time could mask trends that may be present. Such distortion will be increasingly serious to the extent that short-term variability in the mortality rates follows a systematic pattern. However, the results of an earlier analysis (Rowe, 1983) indicate that mortality of the Indian population is variable and that this variability predominantly takes place over short-time intervals. This finding is consistent with the view that accidental deaths are an important element in the mortality of this population. Details of the examination of annual mortality variability may be found in Appendix A.

4.1.3 Aggregation of Death Rates for Life Table Construction

The first step in obtaining reliable age-specific death rates, was to aggregate data into periods of 5 years, 1972-76 and 1977-81, for 8 regions. For each period, regional differences were examined using age-specific

(4) Even after forming five-year age groups, no deaths are observed in several age groups in the smaller provinces on an annual basis.

relative death rates (RDRs) calculated for both sexes and time periods. These rates are obtained by dividing the regional age-specific death rate by the corresponding death rate averaged over all regions for that age group (see Appendix B for details). According to the similarity in mortality levels indicated by the RDRs, the 8 regions were grouped into two main areas - East and West. For example, these rates for the age group 0-1 (infants) ranged from 0.1 to 0.8 for the Atlantic, Quebec and Ontario regions, and, from 0.8 to 1.6 for the remaining western regions of Manitoba, Saskatchewan, Alberta, British Columbia and the Territories (see Figure B1 of Appendix B). Similar clustering of rates occurred for other age groups and on this basis the two areas of East and West were formed. As in the case for infants, rates for other age groups were lower for the East than the West, in both 5-year periods. These differences between East and West were greater in 1977-81 than in 1972-1976, possibly due to a suspected drop in data quality noted in Section 3 for the eastern region. For example, an examination of the infant death rates in Table D3 of Appendix D shows that the ratio of the lowest eastern death rate to the highest western rate has decreased from about a half in 1972 to about a fifth in 1981.

Problems in data quality (see sections 2.1, 3.0 and 4.1.1) suggested caution in interpreting trends in regional mortality levels and differences over the two

periods. The question was then raised as to whether differences in mortality were real or whether they represented differential data quality in terms of regions and time. Given this concern with data quality for the latter period, the 1977-81 age-specific death rates were considered to be too unreliable for assessing trends or constructing regional life tables. As noted in Section 3 the infant death rates in the eastern regions during the 1977-1981 period were below corresponding levels for the total Canadian population. In some regions Indian rates were less then half of the Canadian rate (e.g. Quebec in 1978 with an infant death rate of 5 as compared to 12 for the Canadian population).

4.2. **Estimation Approach**

As indicated earlier, the small population size did not permit the construction of life tables at the provincial or regional level. Age-specific death rates were aggregated by 5-year age groups, from regional levels, into 2 areas, East and West, for 2 time periods, 1972-76 and 1977-81. Data from the latter period, however, were considered unreliable for preparing life tables. Hence, abridged life tables(5) for East and West areas were constructed only for the period 1972-1976. On the basis of these abridged life tables, for 1972-1976 a relational model was developed to estimate life tables for

(5) The distinction between 'abridged' and 'complete' life tables is generally between life tables representing 5-year age groups and single years of age, respectively.

1976 and 1981. The use of a relational model serves as an aid in the smoothing of defective data (see following Section 4.2.1)

Although Indian life tables could have been developed directly at the national level, an indirect approach of developing separate East and West life tables, leading to a national level life table, was preferred. The East and West approach was based on a study of the relative death rates (discussed in Section 4.1.3 and presented in Appendix B). The East-West groupings of the 8 regions resulted from geographic mortality differentials which in general were of greater significance than either the differentials between the sexes or between time periods (see Appendix B). Part of this geographic differential in mortality is probably attributable to the suspected difference in data quality between the East and West, indicated in Sections 3 and 4.1. Due to the difference in data quality between the two areas, and since life tables constructed for each area represent more homogeneous populations than would a national life table, the East-West approach was used. Thus, the relational model was applied separately to the two area life tables in order to differentially smooth their data. The average of these two provides a national life table adjusted for differences in data quality between the regions. In that regard, it will be an improvement upon a national life table constructed directly.

4.2.1 Relational Model

The "relational" model was developed to serve two purposes: firstly, it provided a basis for estimating life tables centered on the years 1976 and 1981, based on the data representing the period 1972-76; and secondly, it provided an appropriate means of obtaining a complete life table from five-year age data (see Appendix C for the technical aspects of the model). The use of a relational model to adjust defective data was pioneered by Brass (1975). The steps in its development can be summarized as follows:

(i) Using 1972-76 age-specific data, 2 sets of abridged life tables were developed, one for the "East", the other for the "West".

(ii) A logarithmic transformation of the life table survivor values, l_x, obtained from the East and West abridged life tables were regressed separately against the corresponding averaged values from the 1971 and 1976 Canadian complete life tables.

(iii) Regression results suggested a reasonable fit between the Canadian and Indian mortality data based on a comparison between the "complete relational" and "abridged" Indian life expectancies. Two sets of fitted equations were developed for the East and West life tables for males and females.

(iv) These fitted equations were combined with the

1976 l_x values from the Canadian complete life table to obtain corresponding 1976 complete life tables for the "East" and "West" regions.

(v) Similarly, the same set of fitted equations were used with the l_x values from the 1981 Canadian complete life table to obtain corresponding 1981 complete life tables for the "East" and "West" groupings of Indian population.

(vi) For both 1976 and 1981, a weighted average of East and West life tables was used to obtain corresponding complete life tables for the total Indian population. The East and West life tables were weighted according to their population. The "East" life table has a lower weight than the "West", since the population of the eastern region is smaller than that of the western region.

The 1981 life tables reflect the assumption that the relationship between the 1972-76 East and West abridged Indian life tables and the averaged 1971 and 1976 abridged Canadian life tables will be the same for 1981. The 1972-76 life tables were based on data incorporating both late reporting of deaths and underreporting of infant deaths.

Mortality rates for infants and the population aged 65+ were estimated independently from the relational model. It was assumed that the 1981 male and female infant mortality rates of the Indian population would decrease from their 1976 levels by about the same percentage as

observed for the 1976 to 1981 Canadian rates. Mortality rates for the population aged 65+ were assumed to be the same as those for the total Canadian population in 1976 and 1981. This approach was used because of the uncertainty associated with the findings noted in Section 3, that Indian death rates at older ages were lower than those for all Canadians.

4.2.2 Comparison Between Indian and Canadian Life Tables

The estimated 1976 and 1981 Indian life tables, may be compared with Canadian life tables for the same years and with those which yield similar life expectancies at birth. As seen in Table 5 the 1976 and 1981 estimated life expectancies at birth for both Indian males and females are about 10 years less than the corresponding values obtained for the Canadian population as a whole. Canadian life tables which yield similar male life expectancies at birth to the 1976 and 1981 Indian estimates of 60 and 62 years are the 1931 and 1941 life tables respectively. For females, the 1976 and 1981 estimated Indian life expectancies at birth of 66 and 69 years are best matched by the 1941 and 1951 Canadian life tables respectively. Thus, the life expectancy at birth of Indian females maintains a lag of about 30-35 years with respect to that of Canadian females, compared to a lag of 40-45 years for Indian males.

The age-specific mortality rates (q_x values) derived from the 1976 and 1981 Indian life tables were compared with the 1941 and 1951 Canadian life table values for both males and females.

Table 5. Life Expectancy at Birth, Registered Indian and Total Canadian Populations, Canada, 1976 and 1981

Year	Registered Indian	Total Canadian	Closest Equivalent Year, Total Canadian
	Male		
1976	59.8	70.2	1931
1981	62.4	71.9	1941
	Female		
1976	66.3	77.5	1941
1981	68.9	79.0	1951

Source: Life expectancies for registered Indian population from life tables by Projections Section, Demography Division, Statistics Canada (Appendix D). See text for details. Life expectancies for total Canadian population from Statistics Canada, Life Tables, Canada and Provinces, Catalogue No. 84-532.

For both males and females a general pattern of differences in age-specific mortality rates emerges between Indian (1976, 1981) and Canadian (1941, 1951) life tables with similar life expectancies. The 1976 and 1981 mortality of Indian infants and the population aged 65 and over is lower than that of Canadians in 1941 and 1951 while Indian mortality for the remaining age groups of 1-4 through 60-64, tends to be higher than that of Canadians in 1941 and 1951. The 1976 and 1981 estimated infant mortality rates for Indians (taking into account late and

underreporting of infant deaths) lag behing those of the Canadian population by about 20 years. If the current infant mortality of the Indian population had been similar to the Canadian rates in 1941 and 1951, the difference in life expectancy between the two would have been even greater. In the case of the population aged 65+, current Indian mortality can be expected to be lower than that of Canadians in earlier years because Indian mortality was assumed to be the same as the current Canadian levels.

A comparison between Indian and total Canadian age-sex specific mortality rates from the 1976 and 1981 life tables indicated that except for the population aged 65+, current age-specific mortality rates for the two populations diverge after infancy, with the greatest divergence occurring in the young adult age groups.

4.3 Comparison of Current Indian Life Tables With Life Tables by Health and Welfare Canada

Life tables for registered Indians were produced by the Medical Services Branch of Health and Welfare Canada (1969) for the 1960-64 and 1965-68 periods. These complete life tables were based on INAC Registry data. From the documentation on these life tables, (Department of National Health and Welfare, 1969) it appears that the data used were not corrected for late reporting or underreporting. As a consequence, the life expectancies produced by these tables are probably over-estimated.

In Table 6, life expectancies at birth from the 1976 and 1981 Indian life tables are compared with the 1960-64 and 1965-68 Indian life tables from Health and Welfare Canada. Compared to life expectancies at birth from the 1976 life table, of 60 years for males and 66 for females, the 1960-64 values are the same for males and less for females. The 1965-68 levels are about the same as the 1976 values for both sexes. These comparisons suggest that the Health and Welfare Canada life tables based on unadjusted data probably resulted in over-estimates of life expectancy.

Table 6. Comparison of Life Expectancies at Birth of Registered Indian Population for Selected Life Tables, Canada 1960-81

Life tables	Life Expectancy at Birth of Registered Indian Population	
	Male	Female
Health and Welfare:		
1960-64	59.7	63.5
1965-68	60.5	65.6
Present study:		
1976	59.8	66.3
1981	62.4	68.9

Source: Life expectancies for periods 1960-64 and 1965-68 produced by Medical Services Branch, Department of National Health and Welfare, 1969.
Life expectancies for 1976 and 1981, Tables D4 and D5.

5. PROJECTION ASSUMPTIONS AND RESULTS

5.1 Possible Approaches

There are several approaches for developing mortality assumptions, such as assuming a gain in life expectancy or a rate of improvement in survival rates based on past trends or expected improvement in living conditions and medical advances. Another is the assumption of a convergency trend to a given level by a given year.

5.2 Development of Assumptions

For purposes of providing a range of mortality levels, two assumptions were offered:

(1) **Constant mortality:** The mortality level and pattern as estimated for 1981 is kept constant throughout the projection period. This provides for the possibility that current mortality levels, apart from those of infants, may be underestimated due to the possible underreporting of deaths at other ages. Since mortality levels generally decrease over time, a constant level represents a high assumption compared to the decreasing mortality assumption.

(2) **Decreasing mortality:** The 1981 Indian mortality levels are assumed to decrease at a rate such that the 1981 total Canadian survival rates are reached in 25 years (i.e. over the next generation).

Because of data quality problems it was difficult to assess long-term trends in mortality. Reasonable estimates of Indian mortality are not available before 1971 since adjustments for late reporting could not be incorporated. Furthermore, current data on deaths would suggest problems of underreporting in certain regions as indicated in Section 3.

The comparisons provided in Section 4, of estimated life expectancies of the Indian population with those of the overall Canadian population, do not indicate a convergence pattern. But, a gradual improvement in Indian life expectancy was estimated. Given the current rate of improvement and a lag of 30 to 40 years, mortality was assumed to decrease at a rate such that estimated current Indian mortality reaches the 1981 overall Canadian levels by the year 2006.

In the decreasing mortality assumption, the rate of improvement in infant survival rates was the same as that projected for most other ages. It was noted in the trends of the adjusted time series that the infant mortality rates of Indians were rapidly converging to Canadian levels unlike other ages. But this convergence was thought to be mainly due to the increase in underreporting for later years. Therefore, current Indian infant survival rates, which are based on adjustments for underreporting are projected at the same rate of improvement as other ages.

The 1981 Canadian mortality levels assumed for the Indian population 65+, were held constant throughout the projection period for both the decreasing and constant assumptions. Depending on the validity of the crossover effect, this could be an over-estimate of Indian mortality for the 65+ population.

Under the decreasing mortality assumption the projected rate of improvement in survival rates implies a gain in life expectancy of about 10 years over the 25-year period. This rate maintains the same time lag in life expectancy in 1996 as that currently observed between the Indian and Canadian population. By 1996 the rate of decrease in mortality yields a projected gain of 6 years and an infant mortality rate of about 17 per thousand births. The projected life expectancy for Indian males and females in 1996 is about 68 and 75 years which correspond to Canadian male and female life expectancies observed in 1956 and 1966 respectively (see Table 7).

Compared to overall mortality levels as measured by life expectancy at birth, Indian infant mortality rates are closer to the Canadian levels. The estimated current infant mortality rates for the Indian population lag behind those of the Canadian population by about 20 years. Under the decreasing assumption, the resulting rate of 17 infant deaths per thousand births for 1996 corresponds to the 1971 Canadian level yielding a lag of about 25 years between the two populations (see Table 8). The projected

Table 7. Estimated and Projected Life Expectancies at Birth for Registered Indian Population, Canada, 1976-1996 with Equivalent Canadian Levels, 1931-1966

Year	Registered Indian	Total Canadian	
		Closest Equivalent Year	Canadian Levels
	Male		
	Estimated		
1976	59.8	1931	60.0
1981	62.4	1941	63.0
	Projected		
1986	63.8		
1991	65.7	1951	66.3
1996	67.7	1956	67.6
	Female		
	Estimated		
1976	66.3	1941	66.3
1981	68.9	1951	70.8
	Projected		
1986	71.0		
1991	73.0	1956	72.9
1996	75.0	1966	75.2

Source: Same as Table 5.

Table 8. Estimated and Projected Infant Mortality Rates for Registered Indian Population, Canada, 1976-1996 with Equivalent Canadian Levels, 1951-1971

Year	Registered Indian	Total Canadian	
		Closest Equivalent Year	Canadian Levels
	Estimated		
1976	37	1951	38.5
1981	27	1961	27.2
	Projected		
1986	25	1966	23.1
1991	21	1971	17.5
1996	17		

Source: Rates for registered Indian population: same as Table 5.
Rates for total Canadian population, Statistics Canada, Vital Statistics Catalogue Nos. 84-204 and 84-206.

infant mortality may be an over-estimate because of the assumption that the rate of improvement in infant survival rates is the same as that assumed for other ages.

5.3 **Evaluation of Results**

This evaluation examines the range in projected deaths produced by the two assumptions of mortality and the relationship between estimated and projected trends in deaths and mortality rates.

When the mortality is kept constant at its 1981 level and fertility is assumed to be rapidly declining,the number of deaths generated by the projection amounts to about 43,200 over the fifteen-year period 1982-96. When the mortality is assumed to decrease, with the same assumption of fertility decline, projected deaths over the 15-year period amount to 37,600. The two sets of assumptions yield a range of 5,600 deaths for the fifteen year period.(6)

The estimated and projected number of total deaths and crude death rates for the Indian population are plotted in Figures 5 and 6 respectively for the periods 1971-81 (estimated) and 1982-96 (projected). Projected numbers of deaths and rates are based on the two mortality assumptions.

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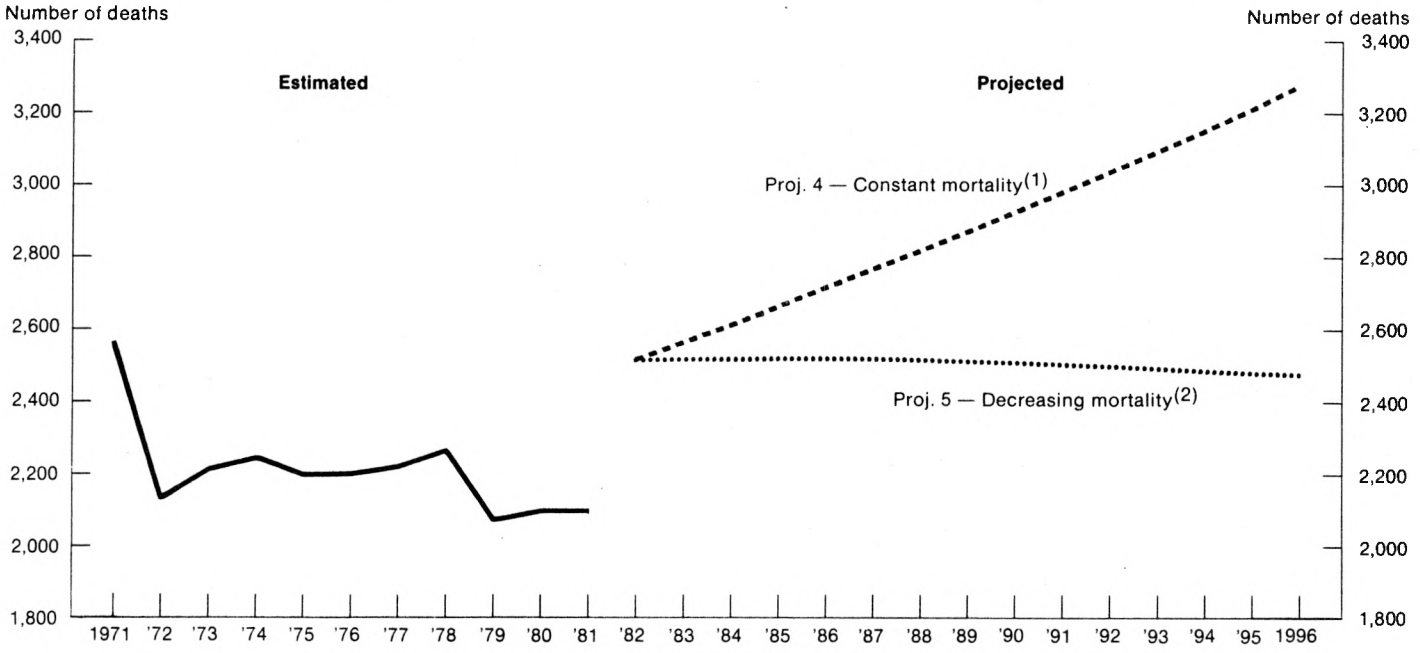
(6) The projections of registered Indians referred to are labelled projections scenarios Nos. 4 and 5, based on constant and decreasing mortality respectively.

Figure 5

Estimated and Projected Number of Total Deaths for the Registered Indian Population, Canada, 1971-96



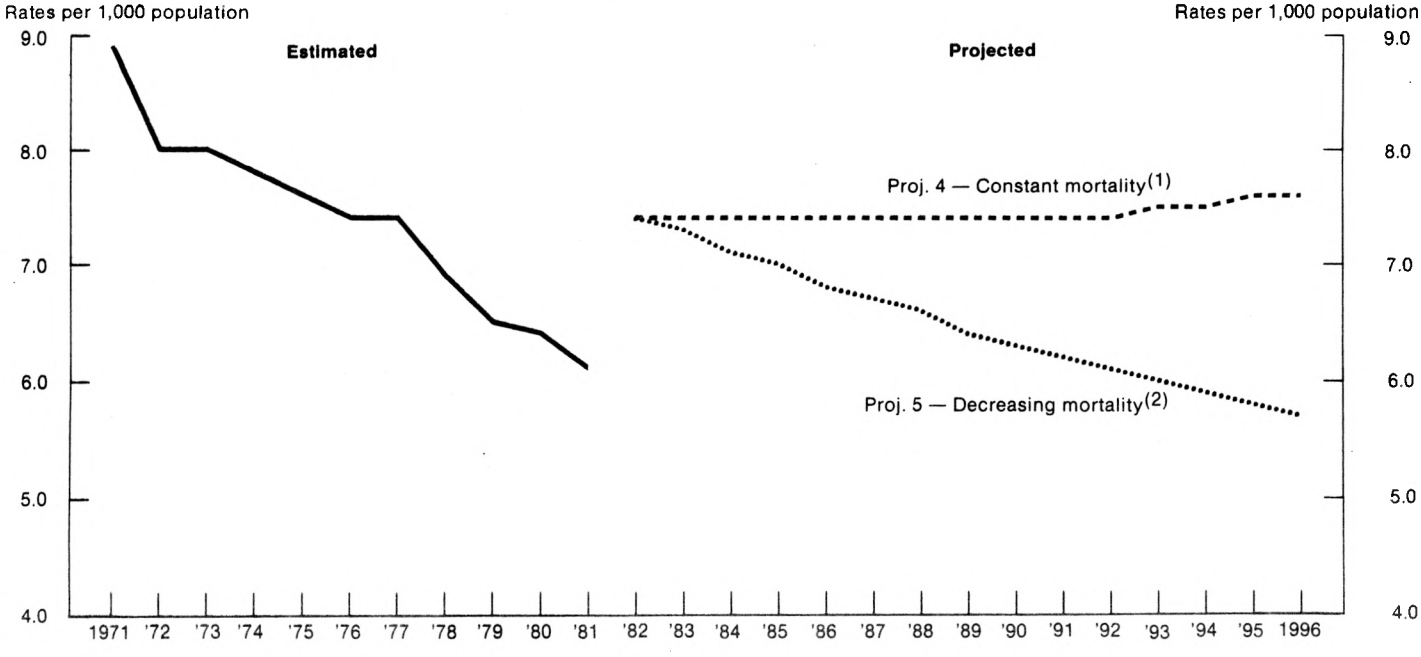
(1) Projection No. 4, for INAC regions is based on assumptions of a rapid decline in fertility and constant mortality.

(2) Projection No. 5, for INAC regions is based on assumptions of a rapid decline in fertility and decreasing mortality.

Source: Estimated, 1971-81: Registered Indian estimates based on Indian Register data adjusted for late reporting of births and deaths by Projections Section, Demography Division, Statistics Canada.
Projected, 1982-96: Population projections of Registered Indians prepared by Projections Section, Demography Division, Statistics Canada.

Figure 6

Estimated and Projected Crude Death Rates for the Registered Indian Population, Canada, 1971-96



(1) Projection No. 4, for INAC regions is based on assumptions of a rapid decline in fertility and constant mortality.

(2) Projection No. 5, for INAC regions is based on assumptions of a rapid decline in fertility and decreasing mortality.

Source: Estimated, 1971-81: Registered Indian estimates based on Indian Register data adjusted for late reporting of births and deaths by Projections Section, Demography Division, Statistics Canada.
Projected, 1982-96: Population projections of Registered Indians prepared by Projections Section, Demography Division, Statistics Canada.

These graphs illustrate the increasing gap between the estimated and projected data on deaths after 1977. The estimated number of total deaths and crude death rates for the 1978-81 period, based on data adjusted for late reporting, appear to be underestimated when compared to the projected numbers and rates starting from 1982. These differences between estimated and projected data reflect the data and approach used in the construction of the 1981 Indian life table. The life table was developed from the relational model which incorporated Indian mortality data, adjusted for underreporting of infant deaths, from the 1972-76 period only, and 1981 life table data for the total Canadian population.

The projected deaths and rates tend to reflect more closely the past trends of the 1972-77 period than the more recent 1978-82 trends. Given the data quality problems in the latter period, the projected trends in the number and rate of total Indian deaths appear to be reasonable.

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Appendix A

Life Table Variance Components

Rowe (1983) provides a set of smoothed life table estimates for each year in the interval 1966-75 for the registered Indian population. These life tables were produced from data which were only partially adjusted, covering a time period which did not fully correspond with the period of interest here, and which employed an unconventional (smoothing) methodology. As a consequence, it is difficult to determine whether the slight decline in life expectancy reported for the overlapping time interval is real or is due to data deficiencies in the early period (1966-70) and to insufficiently adjusted data in the later period (1971-75).

Nevertheless, Rowe's results may be useful in one respect. The methodology employed permits the variability in age specific mortality rates to be divided into three components. These three components are as follows:

(1) Sampling Variability: this component represents the level of variability that would result if differences between succeeding years were random. That is, if changes in expected deaths at an age varied only because the population size changed. This component is termed sampling variability because it regards mortality as if it were a simple random sample from the population.

(2) Long-term Variability: this component represents the effects of mortality variations which persist for more than 1 year in a given age group. One source of long-term effects would be a trend in mortality. However, data deficiencies that were due to persistent underreporting of deaths over periods greater than a year could be another source.

(3) Short-term Variability: this component represents the amount of variation which is uncorrelated with previous years and is in excess of that which could be accounted for by simple random variation. For example certain coding errors could be made in a particular year but not in other years.

Table A 1 provides the estimates of the percent total variability in Indian mortality rates for the years 1966-1975 due to each component in each age group. As may be seen, sampling and short-term variability account for the greater part of the fluctuations in mortality.

Table A 1 Components of Variability (%) in Registered Indian Mortality Rates 1966-1975

Age	Sampling	Long-term	Short-term
Male	%	%	%
0- 1	17.7	6.1	76.2
1- 4	57.6	3.1	39.2
5- 9	29.4	5.2	65.3
10-14	61.5	2.9	35.7
15-19	36.8	4.7	58.5
20-24	26.3	5.5	68.2
25-29	54.3	3.4	42.3
30-34	54.9	3.3	41.7
35-39	49.6	3.7	46.7
40-44	73.0	2.0	25.0
45-49	36.2	4.7	59.1
50-54	32.5	5.0	62.5
55-59	50.8	3.7	45.6
60-64	33.5	4.9	61.5
65-69	54.8	3.4	41.9
70-74	30.7	5.1	64.1
75-79	35.9	4.8	59.4
80-84	54.2	3.4	42.4
Female			
0- 1	23.3	5.9	70.7
1- 4	53.1	3.6	43.3
5- 9	52.5	3.7	43.8
10-14	76.3	1.8	21.8
15-19	46.7	4.1	49.2
20-24	46.9	4.1	49.0
25-29	49.8	3.9	46.3
30-34	61.5	3.0	35.5
35-39	38.1	4.8	57.2
40-44	65.9	2.6	31.5
45-49	43.0	4.4	52.6
50-54	28.4	5.5	66.0
55-59	42.1	4.5	53.4
60-64	33.5	5.2	61.4
65-69	43.7	4.4	51.9
70-74	57.5	3.3	39.2
75-79	31.6	5.3	63.1
80-84	36.6	4.9	58.5

These results give us no information concerning possible effects of data deficiencies that are constant over time. What they do provide is an indication that the mortality of the Indian population is highly variable (in excess of simple random variation) and that this variability predominantly takes place over very short time intervals. The low values of the long-term component suggest that most of the variability is effectively unpredictable. These results may be consistent with mortality that is strongly influenced by the occurence of accidental deaths (either in association with alcohol or other influences).(1)

Finally, the identification of a high level of short-term variability in the mortality rates provides a justification for the use of time-averaged rates in the final construction of life tables. There appears to be little risk of distorting trends, and potentially substantial gains in the stability of rate estimates.

(1) Accidental deaths may be due to circumstances that do not re-occur with regularity (e.g. two cars reaching an intersection at the same time). Disease-related mortality can be associated with dietary and/or health practices or habits which persist over time and are common to many members of a population. Consequently, disease-related death rates are more likely to be correlated between time periods than are accidental death rates.

Appendix B

Aggregation of Regional Data

For purposes of life table construction two options are available for analysis of Indian mortality data, (aggregated into two five-year time periods, by five-year age groups, for each of the eight regions:[1] Atlantic, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, and the Territories).

The first option would be to accept the data as given for each region and to estimate life tables for each (i.e. for both time periods and for both sexes). This option would affect the quality of estimates due to the effect of the small population sizes involved.

Alternatively, greater accuracy could be obtained by aggregating the regions into larger geographic populations - if it is possible to identify similarities in the mortality profiles among the regions. Option two will provide greater reliability to the extent that it is possible to identify contiguous geographic populations with similar mortality.

Plots were developed comparing the Relative Death Rates (RDR) of selected age groups, for both sexes and time periods, by region. The RDRs of a region were calculated for each age group by dividing the age-specific death rate by a corresponding death rate averaged over all regions for that age group.

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(1) These regions are based on provincial boundaries and do not strictly correspond to INAC regions.

Thus, RDRs for different ages could be compared (i.e. differences due to the variations in mortality over age have been removed). The remaining differences among each region's RDRs would be due to differences between the sexes and the time periods.

The RDR plot may be used to identify the geographic structure of Indian mortality. Systematic geographic differentials are represented by blocks of RDRs which are generally either greater or less than 1.0 (i.e. proportionately greater or less than the overall average). If these blocks appear to differ from each other (on average) by a substantial amount, then they necessarily differ by a factor which is greater than either the sex differential or the time trend in each region's mortality. Age group 0-1 (A0) serves as an illustrative case, since mortality in this age group is of particular importance in determining life expectancy. The RDR plot (see Figure B1) corresponding to this age group exhibits a high degree of "blocking" - with the eastern regions (Atlantic, Quebec, and Ontario) forming one distinct block and the remaining western regions forming another.(2)

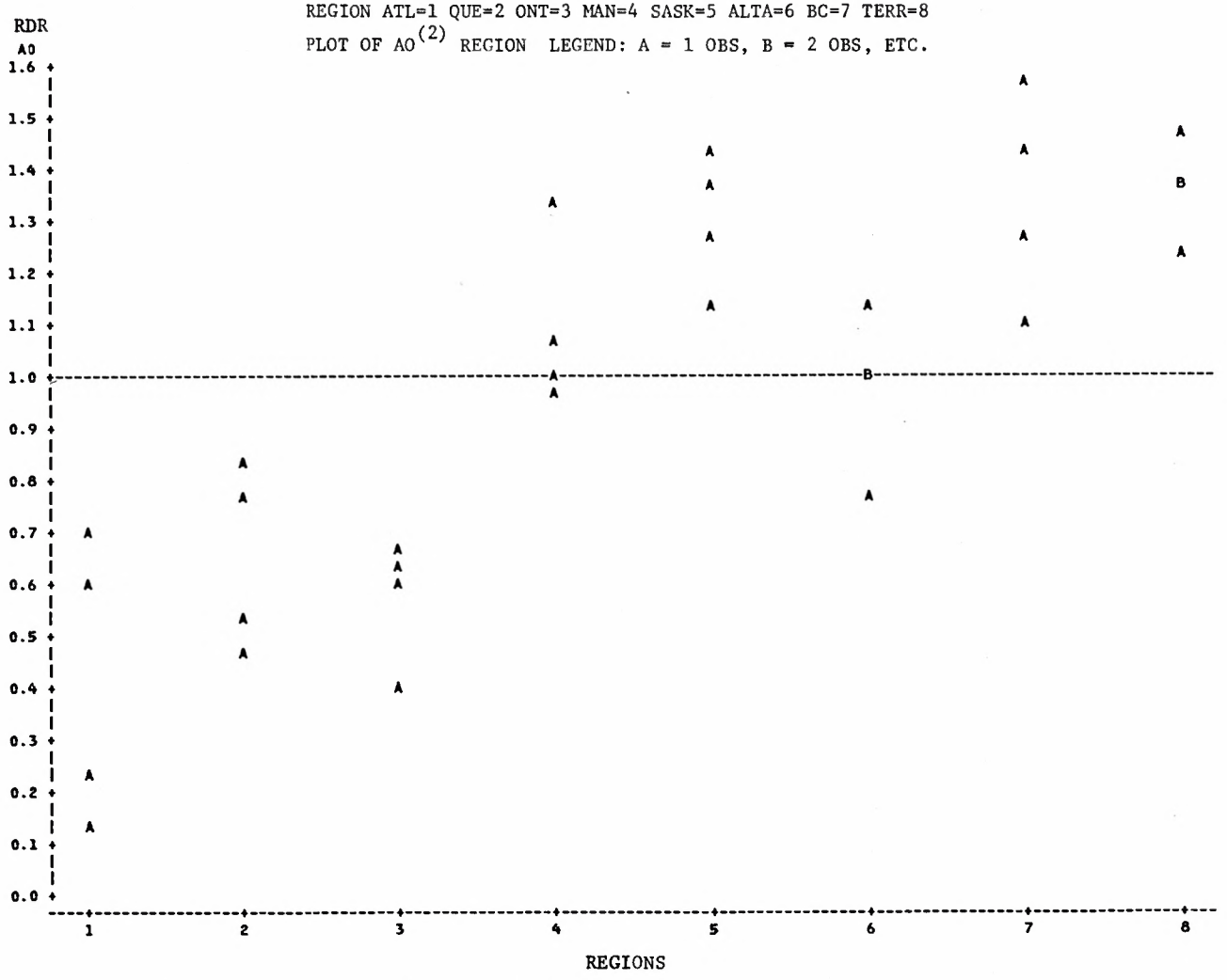
The East-West grouping that resulted from the examination of RDR plots provides an identification of geographic mortality differentials which are, in general, of greater significance than either the differentials

(2) Details for other age groups are available from the authors on request.

Figure B1. PLOTS OF RELATIVE DEATH RATES[1] BY REGION

REGION ATL=1 QUE=2 ONT=3 MAN=4 SASK=5 ALTA=6 BC=7 TERR=8

PLOT OF AO[2] REGION LEGEND: A = 1 OBS, B = 2 OBS, ETC.



(1) The set of relative death rates for each region consists of four rates which correspond to the two time periods, 1972-76 and 1977-81, for males and females separately. If two of these rates have the same values they are both indicated by the letter B, otherwise each value is represented by the letter A.

(2) Rates for age group 0-1.

Source: Adjusted Indian Register data, prepared by Projections Section, Demography Division, Statistics Canada.

between the sexes or between time periods as judged by the size of the differentials. As a consequence, life tables constructed for the East and West areas will represent more homogenous populations than would a national life table, and will be more stable than would life tables for each region taken individually. In that sense, they will provide a more reliable basis for approximating general trends and sex differentials.

Appendix C

The Relational Model - Technical Aspects

1. Data and Their Transformation:

The problem which the relational model addresses is to establish a numerical relationship between relatively unreliable estimates of Indian life tables (provided by five-year age groups) and the known Canadian life tables by single years of age. As such, the purposes of the relational model are (1) to provide a degree of smoothing (i.e. to increase the reliability of the Indian life tables), and (2) to provide the means to convert the Indian life tables to single years of age.

The type of relationship that is estimated by such a model involves the relation between an average and an extreme individual. The Canadian life tables are prepared from data covering all Canadians, and so include the Indian population. In this sense, the Canadian life tables represent the mortality of an average Canadian.(1) As a result of differences in the characteristics and life experience of individuals, the mortality of sub-groups within the Canadian population will be distributed above and below the average. The Indian population represents a sub-group located in the high mortality tail of the Canadian mortality distribution, and the relational

(1) In the subsequent text, references to 'average' mortality refer to Canadian mortality.

model will express the extent of their deviation from the average.

The data employed are estimates of survivorship to exact age x (i.e. l(x)) for both populations. These provide a convenient starting point since both are available for exact corresponding ages, thereby providing a suitable basis for conversion of the Indian survivor curves to single years of age.

Survivor curves have a precise technical definition:

(1) $l(x) = \exp\left(-\int_0^x h(t)\,dt\right) = \exp(-H(x))$

Where h(x) is termed the "force of mortality" and H(x) is the "cumulative force of mortality" or the "cumulative hazard" at each age. A relational model of the form:

(2) $\log(-\log(l^{RI}(x))) = a + b \log(-\log(l^{C}(x)))$

is equivalent to

(3) $\log(H^{RI}(x)) = a + b \log(H^{C}(x))$

where 'RI' denotes the registered Indian population and 'C' denotes the Canadian population.

The model (3) may be interpreted as follows:

(a) after re-arrangement and differentiation it implies that:

(4) $$\frac{dH^{RI}(x)}{dx} = b \cdot \frac{H^{RI}(x)}{H^{C}(x)} \frac{dH^{C}(x)}{dx}$$

(b) the term $\frac{dH^{RI}(x)}{dx}$ represents the change in RI cumulative force of mortality at age x (i.e. the hazard $h^{RI}(x)$),

(c) that change is made up of three component terms:

(i) a relative term representing cumulative divergence in mortality between the two populations, prior to age x, $\frac{H^{RI}(x)}{H^{C}(x)}$

(ii) a term representing the change in H(x) of the Canadian population, $\frac{dH^{C}(x)}{dx}$ at age x (i.e. $h^{C}(x)$- the hazard at age x),

and (iii) a constant factor (b) which inflates (ii) [i.e. relating the hazard in the Canadian population to the hazard in the registered Indian population]

In effect, model (3) corresponds to a model which relates the Indian population to the Canadian average by assuming that age-specific increments in the Indian population's mortality are proportionate to a fixed inflation of the average (Canadian) increment. The inflation factor (b) is assumed to be constant for all ages. More complex models may be employed if the evidence suggests that mortality 'inflation' is more extreme at certain ages than at others. A convenient form for such models is:

$$(5) \quad \log (H^{RI}(x) = a + b_1 \log (H^{C}(x)) + b_2(\log(H^{C}(x)))^2 + \ldots + b_n (\log (H^{C}(x)))^n$$

2. Regression Results

Regressions of the form (5) were estimated for Indian males and females in both East and West regions and both time periods (1972-76 and 1977-81). The Canadian data corresponded to geometric averages of 1971 and 1976 and of 1976 and 1981 official life tables. Regressions were fitted by the ordinary least squares criterion.

The best fitting equations for all time periods, regions, and both sexes had the explicit form:

$$(6)\quad \log\left(H^{RI}(x)\right) = a + b_1 \log\left(H^{C}(x)\right) + b_2 \left(\log\left(H^{C}(x)\right)\right)^2 + b_3 \left(\log\left(H^{C}(x)\right)\right)^3$$

The following table C1 provides regression results in the form of estimated coefficients, and proportions of variance explained. As may be seen, the estimates of 'b_1' are similar in all cases. Differences among regions and sexes appear to be most strongly represented in terms of 'b_2'. With the exception of female East 1977-81, b_2 tends to be larger for females than for males , larger for the West than the East, and larger for 1977-81 than for 1972-76. The term 'b_3' appears to differentiate regions, being generally higher for the West than the East. In the West (where data quality is judged to be best), 'a' is stable.

Regression Estimates

	MALE		FEMALE	
	Coefficients	t-ratios	Coefficients	t-ratios
1972-76				
East				
a	0.240275	9.7	0.174690	7.6
b_1	0.663470	25.8	0.672711	17.0
b_2	0.060209	2.7	0.088253	3.4
b_3	0.032704	7.5	0.033752	7.7
R^2	0.9988		0.9990	
West				
a	0.268293	8.7	0.379472	11.2
b_1	0.643363	20.2	0.671589	11.5
b_2	0.122756	4.5	0.153820	4.0
b_3	0.043350	8.0	0.046778	7.3
R^2	0.9977		0.9977	
1977-81				
East				
a	0.105587	4.4	-0.011955	0.5 *
b_1	0.648756	23.7	0.636180	15.0
b_2	0.077174	3.7	0.027120	1.1 *
b_3	0.036323	9.7	0.020691	5.5
R^2	0.9990		0.9992	
West				
a	0.263764	9.9	0.372236	9.2
b_1	0.649724	21.4	0.759931	10.6
b_2	0.135351	5.9	0.194264	4.6
b_3	0.045625	11.0	0.050979	8.0
R^2	0.9986		0.9976	

* P > 0.05

The model (6) may be represented as:

(7) $\log (H^{RI}(x)) = a + (b_1 + b_2 \log(H^C(x)) + b_3(\log(H^C(x))^2) (\log(H^C(x)))$

in which case, the mortality inflation factor is a function of the rate of increment in average (Canadian) mortality. In these terms, positive 'b_2' corresponds to a generally increasing rate of divergence by age between Indian mortality and average mortality. Consequently, the regression results suggest that

(a) Females diverge more than males do from their respective averages.

(b) The West diverges more than the East.

(c) Divergence is more serious in 1977-81 than in 1972-76.

Subject to further empirical findings, it might indeed be determined that the cumulative impact of Indian mortality causes Indian females to experience relatively greater excess mortality (relative to the female average) than is the case with males. Similarly, in contrast to the comparison of provincial life tables (i.e. for total provincial populations),the RI West - RI East differential may in reality favour the East rather than the West. However, in light of the suspected poorer data quality of the 1977-81 period compared to 1972-1976, findings which suggest that the Indian population is falling rapidly behind the average population may not be accepted at face value. The latter conclusion is especially supported by the anomalous regression results for Female East 1977-81.

APPENDIX D: DETAILED TABLES

- Adjusted Registered Indian Mortality Data, 1971-1981

- 1976 and 1981 Registered Indian Life Tables

Table D1. Total Number of Adjusted Registered Indian Deaths, for Provinces and Canada, 1971-81

Year	Province											
	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	YUKON	NWT	CANADA
1971	4	45	34	244	534	361	419	261	575	25	61	2,563
1972	4	35	52	208	477	270	315	191	504	25	51	2,132
1973	11	52	44	225	487	291	284	238	501	32	48	2,213
1974	5	38	44	200	500	233	354	297	497	21	55	2,244
1975	4	38	24	190	482	265	357	280	463	38	55	2,196
1976	5	50	43	220	479	282	347	278	419	24	53	2,200
1977	8	38	32	185	471	294	381	269	473	15	54	2,220
1978	1	32	31	174	434	298	397	315	492	35	55	2,264
1979	2	49	27	153	454	283	273	260	491	28	52	2,072
1980	4	42	46	188	434	236	297	314	453	26	58	2,098
1981	3	35	34	189	412	292	295	315	451	34	37	2,097

Source: Indian Register data adjusted for late reporting of births and deaths by Projections Section, Demography Division, Statistics Canada.

Table D2. Adjusted Registered Indian Crude Death Rates, for Regions and Canada 1971-81

Year	Region								
	ATLANTIC	QUE	ONT	MAN	SASK	ALTA	BC	TERRITORIES	CANADA
1971	8.4	7.7	8.7	8.4	9.6	7.4	10.8	8.6	8.9
1972	9.3	7.2	8.1	7.2	7.6	6.8	9.9	8.1	8.0
1973	8.9	7.0	8.0	6.5	7.8	8.2	9.6	7.9	8.0
1974	6.8	6.3	7.8	6.0	8.5	8.7	9.1	8.4	7.8
1975	7.2	6.5	7.5	6.5	8.1	8.2	8.2	8.3	7.6
1976	7.5	6.6	7.0	6.6	8.2	7.8	8.1	7.0	7.4
1977	5.9	5.5	6.7	6.6	8.5	8.1	8.6	7.5	7.4
1978	5.8	4.9	6.4	6.4	7.1	7.7	8.6	7.9	6.9
1979	6.8	5.0	6.3	5.5	5.9	7.5	8.1	7.4	6.5
1980	6.4	5.5	5.9	5.5	6.0	8.0	7.6	7.7	6.4
1981	5.5	5.6	5.2	5.4	6.0	7.6	6.9	7.9	6.1

Source: Same as Table D1.

Table D3. Adjusted Registered Indian Infant Death Rates, for Regions and Canada 1971-81

Year	Region								
	ATLANTIC	QUE	ONT	MAN	SASK	ALTA	BC	TERRITORIES	CANADA
1971	25.5	34.2	26.7	45.5	63.9	29.8	55.1	57.7	43.2
1972	25.9	41.0	21.5	39.3	47.0	26.9	44.3	46.4	36.2
1973	25.1	23.1	24.7	30.3	45.5	31.1	41.4	35.0	33.1
1974	22.3	14.7	23.7	25.7	45.6	32.8	36.4	47.8	31.2
1975	13.0	15.6	17.0	26.6	42.0	26.1	33.3	50.2	27.6
1976	3.2	18.4	12.0	26.4	38.4	22.8	36.5	37.1	25.7
1977	3.0	13.3	11.6	25.4	32.7	21.8	30.5	30.9	22.6
1978	4.6	5.0	9.7	21.1	22.6	20.9	24.8	36.6	18.3
1979	3.0	8.4	8.6	21.0	18.9	21.5	26.6	29.3	17.7
1980	4.2	8.0	9.8	21.6	17.1	18.4	28.0	12.2	17.1
1981	5.4	6.5	7.9	18.6	12.9	16.9	28.6	8.7	15.1

Source: Same as Table D1.

Table D4. Abridged Life Table, 1976
Registered Indian Population, Canada

Age group	L	D	P	Q	LL	T	E
			Male				
0-1	100000	3886	0.9611	0.0389	96503	5971739	60
1-5	96114	2776	0.9711	0.0289	376344	5875236	61
5-10	93338	685	0.9927	0.0073	464761	5498892	59
10-15	92653	647	0.9930	0.0070	461903	5034131	54
15-20	92006	2207	0.9760	0.0240	455251	4572228	50
20-25	89799	3112	0.9653	0.0347	441224	4116977	46
25-30	86687	2538	0.9707	0.0293	426783	3675753	42
30-35	84149	2242	0.9734	0.0266	415177	3248970	39
35-40	81907	2662	0.9675	0.0325	403164	2833793	35
40-45	79245	3579	0.9548	0.0452	387740	2430629	31
45-50	75666	4889	0.9354	0.0646	366646	2042889	27
50-55	70777	6067	0.9143	0.0857	339133	1676243	24
55-60	64710	6946	0.8927	0.1073	306461	1337110	21
60-65	57764	7457	0.8709	0.1291	270332	1030649	18
65-70	50307	7836	0.8442	0.1558	273781	760317	15
70-75	42471	8401	0.8022	0.1978	149948	486536	12
75-80	34070	8993	0.7360	0.2640	148096	336588	10
80-85	25077	9337	0.6277	0.3723	102037	188492	8
85-90	15740	8467	0.4621	0.5379	56779	86455	5
90+	7273	7273	0	1.0000	29676	29676	4
			Female				
0-1	100000	3422	0.9658	0.0342	96920	6626687	66
1-5	96578	2542	0.9737	0.0263	378862	6529767	68
5-10	94036	635	0.9932	0.0068	468444	6150905	65
10-15	93401	520	0.9944	0.0056	465774	5682461	61
15-20	92881	974	0.9895	0.0105	462167	5216687	56
20-25	91907	1159	0.9874	0.0126	456637	4754520	52
25-30	90748	1170	0.9871	0.0129	450848	4297883	47
30-35	89578	1489	0.9834	0.0166	444364	3847035	43
35-40	88089	2163	0.9754	0.0246	435372	3402671	39
40-45	85926	3123	0.9637	0.0363	422288	2967299	35
45-50	82803	4425	0.9466	0.0534	403432	2545011	31
50-55	78378	5240	0.9331	0.0669	379068	2141579	27
55-60	73138	5997	0.9180	0.0820	350974	1762511	24
60-65	67141	6505	0.9031	0.0969	319616	1411537	21
65-70	60636	6960	0.8852	0.1148	285991	1091921	18
70-75	53676	7592	0.8586	0.1414	249720	805930	15
75-80	46084	8613	0.8131	0.1869	209431	556210	12
80-85	37471	10243	0.7266	0.2734	162466	346779	9
85-90	27228	11775	0.5675	0.4325	107413	184313	7
90+	15453	15453	0	1.0000	76900	76900	5

Source: Life tables estimated by Projections Section, Demography Division, Statistics Canada, based on analysis of adjusted Indian Register data.

Table D5. Abridged Life Table, 1981
Registered Indian Population, Canada

Age group	L	D	P	Q	LL	T	E
			Male				
0-1	100000	2776	0.9722	0.0278	97501	6243456	62
1-5	97224	1784	0.9817	0.0183	383873	6145955	63
5-10	95440	476	0.9950	0.0050	475830	5762082	60
10-15	94964	509	0.9946	0.0054	473801	5286252	56
15-20	94455	1864	0.9803	0.0197	468262	4812451	51
20-25	92591	2734	0.9705	0.0295	456193	4344189	47
25-30	89857	2470	0.9725	0.0275	442916	3887996	43
30-35	87387	2176	0.9751	0.0249	431478	3445080	39
35-40	85211	2481	0.9709	0.0291	420105	3013602	35
40-45	82730	3353	0.9595	0.0405	405735	2593497	31
45-50	79377	4750	0.9402	0.0598	385625	2187762	28
50-55	74627	6165	0.9174	0.0826	358224	1802137	24
55-60	68462	7167	0.8953	0.1047	324698	1443913	21
60-65	61295	7740	0.8737	0.1263	287311	1119215	18
65-70	53555	8187	0.8471	0.1529	247475	831904	16
70-75	45368	8623	0.8099	0.1901	205495	584429	13
75-80	36745	9248	0.7483	0.2517	160864	378934	10
80-85	27497	9650	0.6491	0.3509	113374	218070	8
85-90	17847	8898	0.5014	0.4986	66318	104696	6
90+	8949	8949	0	1.0000	38378	38378	4
			Female				
0-1	100000	2444	0.9756	0.0244	97800	6891045	69
1-5	97556	1428	0.9854	0.0146	386175	6793245	70
5-10	96128	418	0.9957	0.0043	479493	6407070	67
10-15	95710	381	0.9960	0.0040	477672	5927577	62
15-20	95329	773	0.9919	0.0081	474894	5449905	57
20-25	94556	980	0.9896	0.0104	470360	4975011	53
25-30	93576	1108	0.9882	0.0118	465180	4504651	48
30-35	92468	1320	0.9857	0.0143	459184	4039471	44
35-40	91148	1946	0.9787	0.0213	451226	3580287	39
40-45	89202	2972	0.9667	0.0333	439056	3129061	35
45-50	86230	4210	0.9512	0.0488	421154	2690005	31
50-55	82020	5518	0.9327	0.0673	396777	2268851	28
55-60	76502	6406	0.9163	0.0837	366746	1872074	24
60-65	70096	6858	0.9022	0.0978	333486	1505328	21
65-70	63238	7243	0.8855	0.1145	298237	1171842	19
70-75	55995	7667	0.8631	0.1369	261045	873605	16
75-80	48328	8529	0.8235	0.1765	220805	612560	13
80-85	39799	10030	0.7480	0.2520	174602	391755	10
85-90	29769	11456	0.6152	0.3848	120552	217153	7
90+	18313	18313	0	1.0000	96601	96601	5

Source: Same as Table D4.