INTERMETROPOLITAN COMPARISONS OF MORTALITY PATTERNS IN CANADA 1976

By

JERRY DONALD MURYN

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ABSTRACT

This paper is a descriptive analysis of differences in mortality rates among Canada's 23 Census Metropolitan Areas in 1976. Life Table output focuses specifically on the life expectancies and standardized mortality rates as a means to identify CMA mortality differences. With mention to relevant cause-specific studies and use of regression analysis an attempt is made to shed some light on the identified mortality patterns. Major findings are (1) that mortality rate variation among CMAs reveals an east-west spatial arrangement - mortality rates in Atlantic, Quebec, and Northern Ontario CMAs are above the Canadian average while the mortality rates of Southern Ontario and Western CMAs are at or below the Canadian average; (2) that Victoria CMA is dominant among the CMAs in 1976 in terms of favourable mortality probability; (3) that male mortality rates are significantly higher than female mortality rates but tend to be positively related; (4) that health expenditures per capita have significant influence on health status but continued research is necessary to study and gain a fuller understanding of the effects of various explanatory variables on mortality.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

Previous demographic studies of mortality in Canada have generally limited themselves to analyzing mortality indexes, arranged in the form of life tables, at the broad regional level. As a result, the provinces, or their aggregates, have become the basic geographical units of observation. Despite the fact this approach could offer regional conclusions, the mortality conditions of the specific metropolitan areas have been concealed within the overall framework. Instead of simply assuming that metropolitan rates reflect the overall regional rates there is a need to investigate mortality specifically among the Census Metropolitan Areas (CMA). Recently, with the increasing importance of medical geography, mortality patterns based on varying causes of death at the urban/rural level of observation have been examined through cartographic analysis. Several of these cause-specific studies have shown that mortality rates tend to be higher in the Atlantic and Quebec regions in comparison to Ontario and the Western regions (Field 1976, Health and Welfare Canada 1980, 1980a, and 1984). However, little emphasis has been placed on explaining these patterns by identifying the influence of explanatory variables on differential mortality. Therefore, from a demographic standpoint, additional mortality insights could be obtained with respect to spatial patterns and intermetropolitan mortality relationships by studying the CMAs. From a medical geographical standpoint, some reasons can be offered to account for the observed patterns. This paper will focus primarily on a demographic/descriptive analysis of mortality.

The purpose of this research report is to study the mortality rates among Canada's 23 Census Metropolitan Areas in 1976. An attempt will be made to search for significant metropolitan mortality patterns and to identify unusual mortality rates. Through this analysis of spatial variations, an attempt will also be made to provide possible explanations for the presense of high and low risk CMAs through references to possible underlying causal factors. This report consists of five sections. First, the CMA and its importance as a unit of observation will be mentioned. Second, an in-depth review of mortality data will be presented, discussing the limitations of the data and results, mortality recording procedures in Canada and data collection. Third, the method of analysis, part A, will examine the life table as an instrument for measuring mortality; the relevant life table output, male and female life expectancies at birth, will be studied across the CMAs to identify significant relationships. Part B will deal with standardized mortality as a second, more informative method to measure mortality. The standardized rates will be compared among the CMAs by age groupings and sex to detect significant mortality spatial variations and relationships. Fourth, possible reasons to account for the unusual mortality observations are offered with reference to previous research. In addition, statistical analysis is used to indicate the influence of certain socio-economic indicators on mortality. Finally, in light of the evidence presented, the main findings are summarized and discussed.

2. CENSUS METROPOLITAN AREAS - UNIT OF OBSERVATION

2.1 Definition

According to Mitchell et. al.(1980), the Canadian Census Metropolitan Area (CMA) is defined as the main labour market area of an urbanized core (or continuous built-up area with not more than 1 mile discontinuity) that consists of a population of 100,000 or greater. CMAs are created by Statistics Canada and are usually known by the name of their largest city; in 1976 Canada had 23 CMAs (Figure 1.). The CMAs contain whole municipalities (census subdivisions) and are comprised of municipalities completely or partly inside the urbanized core, and the municipalities, if "at least 40% of the employed labour force residing in the municipality works in the urbanized core, or at least 25% of the employed labour force working in the municipality reside in the urbanized core."

2.2 The Census Metropolitan Area as a Unit of Study

There is an advantage in using CMA mortality figures instead of provincial figures. By studying on a smaller scale, hence the CMA, it is easier to pinpoint certain causal mechanisms. Thus, it can be determined whether CMAs in the specific province reflect similar overall differences in mortality among the provinces as a whole.

In 1976, 56% of the entire Canadian population lived in the CMAs, and 53% of Canada's death total was from the CMAs.* Not only are the CMAs representative of Canada as a whole they also provide relevant

*These values were calculated from 1976 Statistics Canada data provided (adjusted for underenumeration);

i) $\frac{\text{Combined CMA population}}{\text{Total Canadian Population}} = \frac{13068171}{23471843} \times 100 = 55\%$

ii) $\frac{\text{Total Male/Female CMA Deaths}}{\text{Total Canadian Deaths}} = \frac{89426}{168498} \times 100 = 53\%$

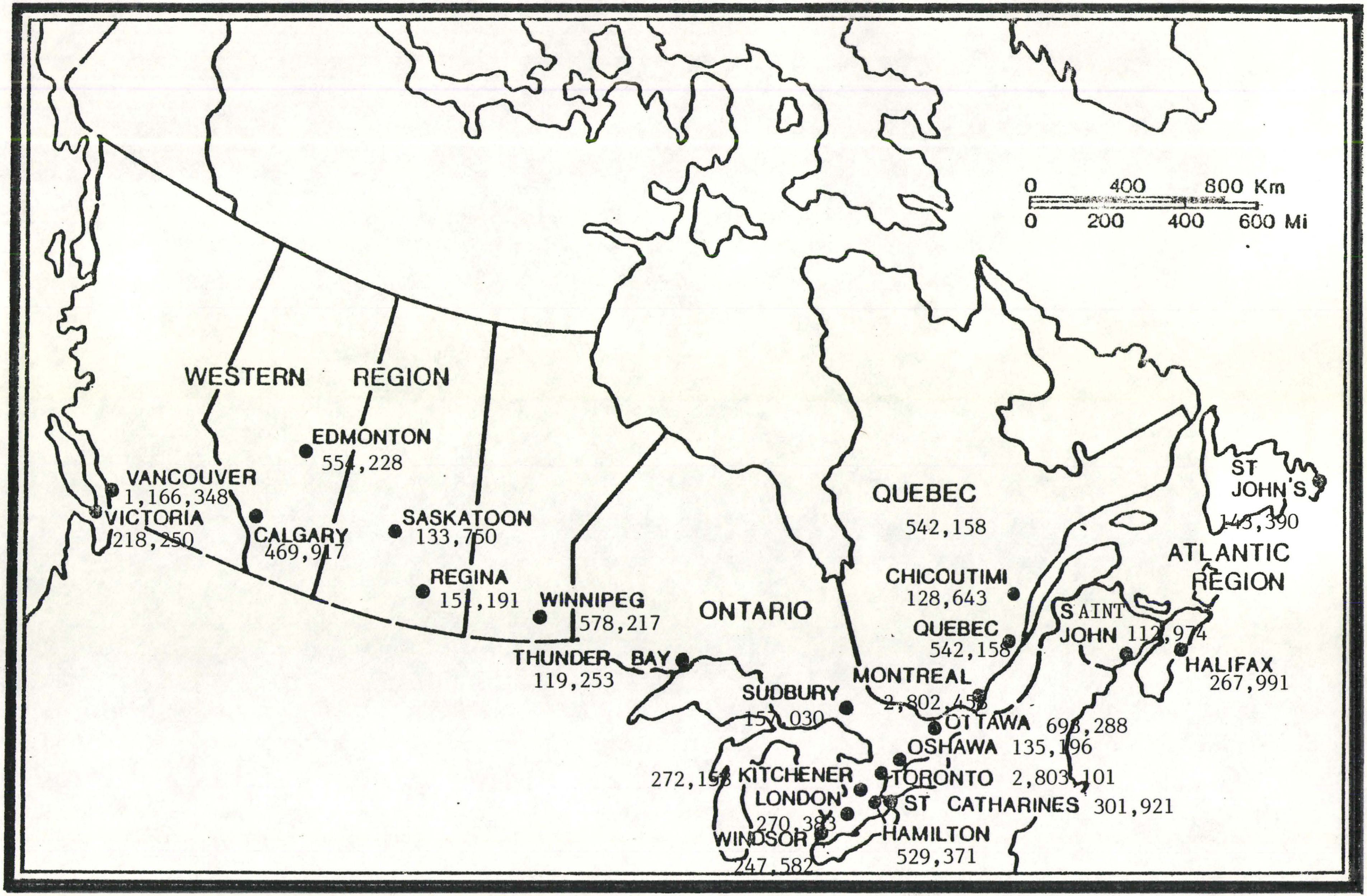

FIGURE 1. The Locations and Populations of Canadian Census Metropolitan Areas, 1976

source: Statistics Canada

information of urban Canada's characteristics. At the present time, Statistics Canada provides mortality data at the provincial level but does not provide CMA-specific mortality figures. Hence, easy access to provincial data has encouraged provincial mortality studies while the difficulty in obtaining, or unavailabity of, CMA data has discouraged CMA mortality research.

The study of mortality at the provincial level is only the first step in identifying mortality differential across Canada. Specific metropolitan mortality contributions to the regional structure are a necessary second step in identifying urban mortality differences. Therefore, as urban areas and cities continue to expand and newer CMAs are formed there is a definite need to study and understand intermetropolitan mortality patterns. Perhaps, this research report will encourage demographers or other researchers to investigate mortality at the CMA level.

3. MORTALITY DATA

3.1 Limitations of Data, Results, Interpretations

Prior to discussion the general mortality-recording procedures and data collection relevant to this study, some important data limitations or cautions in the interpretation of results need to be reviewed.

i) A sub group (age interval) in a given city may have an extremely low mortality rate because it is not exposed as an at-risk population. This occurs primarily within the 1-14 age group. For example, the standardized mortality (per 10,000) of Oshawa's females, age 1-14, is 0.00. The at-risk population is small, and thus, despite the absence of deaths, the observed rates within this age group are not meaningful.

ii) The time between the exposure to some factor and the resulting death, especially with respect to disease, may involve years or decades. Between this time lag an individual could possibly move to another region; as a result, mortality studies among cities should consider the intermetropolitan mobility of population. For example, between 1967 and 1981, approximately 11% of the Canadian population aged 45 years or over moved from one municipality to another. (Health and Welfare Canada, 1984). Specifically, a person in city X may move to city Y and die there as a result of conditions suffered in city X. Therefore, one must keep in mind, especially in longer range studies, that the movement of people between cities can possibly conceal real metropolitan mortality rates. risks

iii) One specific factor can not be used in explaining a high mortality rate in a given city. The explanation of excess mortality requires epidemiologic studies to determine the importance of several factors relating to lifestyle, occupation and environment. (Health and Welfare Canada, 1980a).

IV) Based on vital statistics for a single year, 1976, the study is cross sectional. Because of observations at one time period the absence of excess mortality in a given city need not be interpreted as an area free of health problems. Conversely, the presence of excess mortality in a given city need not be interpreted as an area of substantial health problems. To negate this problem, relevant pre-1976 and post-1976 data and information will be consulted, which in turn, will allow for inferences to be made about 1976 mortality rates. By allowing for a wider observation period, the short-term mortality fluctuations that result from chance factors could possibly be eliminated and conclusions would have greater reliability. (Basavarajappa and Lindsay, 1976).

3.2 Mortality Recording Procedures in Canada

According to Health and Welfare Canada (1984), the provincial and territorial governments, under appropriate Vital Statistics or other Acts, are responsible for the registration of deaths and other vital events (births, marriages, divorces, etc.). Under these Acts, vital elements must be reported within a prescribed time period and specific statistical information must be recorded. The necessary information includes cause of death, residence, sex and age or birth date of the deceased. Under a federal-provincial agreement, copies of these registration documents and, where usable, machine-readable abstracts of the registration documents are sent to Statistics Canada for compilation. Before collection of national statistics,

Statistics Canada inspects the abstracts for internal consistency and then all records are compared to the corresponding registration documents to correct any errors.

Despite the organized manner in which the data is obtained and examined, the following sources of errors which may affect mortality data and the reliability of mortality rates are possible (Health and Welfare Canada, 1980):

i) Completeness of Registration - it is believed that registration approaches one hundred percent mainly because of the legal requirements involved. However, a very small percentage of deaths is not included in the compilations because registrations are received after operational cut-off dates.

ii) Recording of Data - death registrations are legal documents and are reviewed at the time of completion and during filing in the provincial offices. It is safe to assume that the records are complete and accurate.

iii) Coding and Processing Errors - errors of this type have greater significance with respect to rural areas where postal address, instead of place of residence is recorded and then coded. Thus, this error may be less prevalent among CMAs.

3.3 Data Collection

The necessary data was provided by Dr. D. N. Nagnur of Statistics Canada. The data set of the 1976 Canadian population contained sex-specific records disaggregated by age and region. There are 25 regions (the 23 CMAs, the rest of Canada, and Canada) and 92 age groups (0, 1, 2,

...90+, total). The other data set contained sex-specific 1976 deaths for the same age and regional disaggregation, which has been adjusted for underenumeration. The deaths of unknown ages were allocated by a computer programme into the known age groups. It is important to note that the age by year values for Canada are not obtained as the sums of the adjusted regional values. Instead, they are adjusted from the original national values into the various age groups. As a result, the consistency of the death file depends on the accuracy of the input data.

The male and female population and death records for each CMA, the rest of Canada and Canada (total) for 1976 are in the period between January 1, 1976 and December 31, 1976.

4. METHOD OF ANALYSIS

4.1 Part A - Life Table Construction

Several methods can be used to measure and analyze mortality. With the data provided and through several computer programming operations the main focus has been on the construction of a male and female life table for each of the 25 regions. The computing and printing of the life table was performed by the subroutine LIF (Keyfitz and Flieger, 1971), a program that translated the demographic theory into FORTRAN. Additional FORTRAN programmes were constructed and combined with LIF as a complete computer package in order for input data to be read and arranged in life table form.

The life table is a method of summarizing mortality and it simply expresses in compact form the age-specific mortality rates of a given place during a given time period (Overbeek, 1980). The precise techniques most often used in life table construction are too involved be of general interest or significance; despite these complexities, the general outlines of constructing a life table are relatively simple. First, age-specific data on deaths and the at-risk population are needed. Second, the at-risk population has to be adjusted for underenumeration. Third, the death rates for each age group can then be computed. With respect to the second step, the highest underenumeration rates in Canada in 1976 occured within the 20-24 age group for both males and females (Statistics Canada, 1980). In the 1976 population census the overall underenumeration rate was 2.0%; for males, 2.5%, and for females, 1.6% (Ibid). Highest male rates were recorded in British Columbia, 3.6%, and Quebec, 3.4%, and similarily, highest female rates were also recorded in British Columbia, 2.7%, and Quebec, 2.5%, respectively (Liaw, 1979).

Smith and Zopf (1970) state that three typical problems relating to the data include determining the population of less than one year of age, calculating the average age of deaths of infants who die before age one, and errors associated with the reporting of age. Specifically with respect to the first two problems, there is often a lack of precision in enumerating children of less than one year of age, incomplete birth registrations and the rapid flow of vital events during the first year of life. As a result of these 'expected' problems, when the age-specific death rates are calculated for the construction of the life tables they are exposed to an elaborate mathematical smoothing process; the purpose of which is to remove fluctuations that are due merely to random events or pure chance (Ibid).

The remainder of the life table is produced by starting in a specified year with a hypothetical cohort of 100,000 at age zero called the 'radix' of the life table (Overbeek, 1980). In other words, for the purposes of calculation, it is assumed that 100,000 babies are all born on the same day (Johnston, 1981). The age-specific death rates for the year in question (in this case, 1976) are applied to the radix and then the life table determines how many members of the original cohort will die in each age interval and how many survive each year (Overbeek, 1980). This process continues until the last surviving member of the radix dies. Thus, the summary is the life table.

Life tables (Johnston, 1981) were first constructed to compute for each age group the probability of dying, the number of deaths, the number of survivors and the average life expectancies of the survivors for life assurance premiums. Life tables are also used as structural models for population growth and projection studies as well as a summary of mortality characteristics in comparing different countries.

There are two types of life tables: longitudinal and cross-sectional (time specific) (Overbeek, 1981). The cross sectional approach is widely used by demographers, planners and insurance companies. Because this study is based on the time specific 1976 observations the cross sectional life table is used. To gain a better understanding of the life table's output and importance a 1976 male life table of

Table I: Male Life Table For Hamilton CMA, 1976

AGE	PP	DD	Q(X)	L(X)	D(X)	LL(X)	AGE
0	3665	54	.014540	100000	1454	98684	0
1	15609	7	.001792	98546	177	393742	1
5	21833	13	.002973	98369	292	491116	5
10	26326	16	.003034	98077	298	489647	10
15	27112	18	.003317	97779	324	488153	15
20	24216	31	.006388	97455	623	485762	20
25	22608	25	.005508	96832	533	482800	25
30	18965	19	.005019	96299	483	480381	30
35	16045	33	.010284	95816	985	476801	35
40	15791	46	.014472	94830	1372	471054	40
45	16411	92	.027674	93458	2586	461364	45
50	16315	145	.043618	90872	3964	445014	50
55	12171	152	.060968	86908	5299	422170	55
60	10336	216	.100191	81609	8177	389093	60
65	7499	275	.169449	73433	12443	337383	65
70	5457	294	.238494	60990	14546	269138	70
75	3470	268	.325147	46444	15101	194324	75
80	1774	203	.442202	31343	13860	121120	80
85	1192	207	1.000000	17483	17483	100674	85

AGE	M(X)	A(X)	TT(X)	R(X)	E(X)	MM(X)	AGE
0	.014734	.095	7098428	.0000	70.984	.014734	0
1	.000448	1.500	6999744	.0000	71.030	.000448	1
5	.000595	2.500	6606001	.0000	67.155	.000595	5
10	.000608	2.522	6114885	.0000	62.348	.000608	10
15	.000664	2.709	5625237	.0048	57.530	.000664	15
20	.001282	2.570	5137084	.0139	52.712	.001280	20
25	.001105	2.446	4651321	.0186	48.035	.001106	25
30	.001006	2.695	4168521	.0311	43.287	.001002	30
35	.002067	2.688	3688140	.0238	38.492	.002057	35
40	.002914	2.743	3211339	.0004	33.864	.002913	40
45	.005606	2.709	2740284	.0000	29.321	.005606	45
50	.008907	2.643	2278920	.0143	25.078	.008888	50
55	.012551	2.666	1833906	.0293	21.102	.012489	55
60	.021014	2.682	1411735	.0264	17.299	.020898	60
65	.036881	2.607	1022641	.0284	13.926	.036672	65
70	.054045	2.538	685258	.0199	11.236	.053876	70
75	.077711	2.491	416120	.0370	8.960	.077233	75
80	.114431	2.432	221795	.0000	7.076	.114431	80
85	.104981	5.758	100675	.0000	5.758	.173658	85

Hamilton, Ontario is reviewed and the tables' properties* will be defined (table I).

This table is commonly referred to as an abridged life table because 5 year age classes are used. The only exception is age 0; age 0 simply means under 1 year of age. Age 1 means 1 or more years of age and less than age 5. Age 5 means 5 or more years of age and less than age 10, etc. The last age group, 85, consists of all remaining ages so this last age category should be stated as 85+.

PP - the observed population by age
- the 1976 Hamilton newborn male infant population at age 0 was 3,665

DD - the observed number of deaths by age
- in Hamilton, 92 males died who were between the ages 45-49.

Qx - or $_nq_x$
- the probability of dying for an individual of exact age x, before reaching age x+n, where the value of n for the first line is 1, 4 for the second, and 5 for the remaining lines up to the open interval, 85+.
- in Hamilton, the probablility of a male newborn, age 0, dying before reaching age 1 is 0.014540 ($_1q_0$= 0.014540)

Lx - or lx
- the number surviving to exact age x out of an original 100,000 born where x=0,1,5,10,15,...85.
- calculated as; lx=lx-n (1-n qx-n)
- this symbol can also be seen as the probablility that a child just born will survive at least to exact age x by dividing the value L(x) by 100,000
- in Hamilton, of the 100,000 males born, 60,990 of them will survive to their 70th birthday (l_{70}=60,990).

Dx - or $_nd_x$
- the number of individuals dying between ages x and x=n out of 100,000 born.
- this can also be interpreted as the probability that a child just born will die between some age x and x=n by dividing by 100,000
- calculated as: $_nd_x = l_{x\,n}q_x$

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*for interpretations of symbols and calculations the author referred to Keyfitz and Flieger (1968, 1971).

Dx - in Hamilton, of the 100,000 males born, 1,454 males will die before reaching age 1 ($_1d_0$=1454).

LLx - or $_nL_x$

- the number of person-years lived between ages x and x+n by a birth cohort of 100,000 individuals - same as stationary age distribution
- calculated as: $_nL_x = \int_0^n l(x+t)dt$
- in Hamilton, the males between ages 20-24 have lived a total of 485,762 years ($_5L_{20}$=485,762).

Mx - or $_nm_x$

- age-specific death rate in hypothetical life table population for interval x to x+n
- calculated as: $_nm_x = \frac{ndx}{_nL_x}$
- in Hamilton, the age-specific death of males aged 80 is 0.114431
- ie: 114 males out of 1000 will die in their 80th year. ($_5m_{80}$=0.114431)

Ax - or $_n x$

- the mean number of years lived in the interval x to x+n by those dying during the interval
- calculated as: $_5a_x = \frac{_5L_X - _5l + 5}{_5d_x}$
- in Hamilton, from age 35 to 39 the average number of years lived by those males during this interval is 2.688 years. ($_5a_{35}$=2.688)

TTx - or Tx

- the total number of years lived beyong age x per 100,000 born
- in Hamilton, all males surviving to age 5, from 100,000 born, have lived a total of 6,606,001 years. (T_5=6,606,001)

Rx - or rx

- the increase from one annual cohort to the next as estimated from the observed age distribution.

Ex - or $\mathring{e}x$

- the expectation of life at age x
- ie: the average number of years lived subsequent to age x by those individuals reaching age x
- calculated as: $\mathring{e}x$=Tx/lx
- in Hamilton, a male child just born, on average, has a life expectancy of 70.984 or 71 years
- a 25 year old Hamilton male, on average, has 48.035 or 48 years of life remaining. (e_{25}=48)

MMx - or nMx
- observed age-specific death rate for age interval x to x+n, to which the life table has been iterated.
- calculated as: $nMx = \frac{\text{number of observed deaths in age group } x}{\text{population in age group } x} = \frac{DD_x}{PP_x}$
- in Hamilton, the observed age-specific death rate of males between the ages 50-54 is 0.008888 or about 9 in 1000. ($_5M_{50}$=0.008888)

4.2 CMA Life Expectancy Study

From the life table output the life expectancies at birth will be used as an initial summary measure of mortality for the 25 regions. Later the technique of standardization will be explained and the life table output will be manipulated to reveal more specific mortality information. For the time being, however, the life expectancies at birth for the 23 CMAs, the rest of Canada and Canada will be examined in order to detect any significant patterns or relationships. (table II) Before proceeding it is important to note that 'life expectancy at birth' is the average number of years to be lived starting from birth by an individual. The life expectancy at birth is usually less than the life expectancy at age one, because mortality declines rapidly during the first year after birth. (Johnston, 1981). This at-birth expectancy value is not only a convenient way of summarizing the state of mortality, it is also, to some extent, an overall indicator of the health status of the population. Therefore, an examination of the 1976 CMA life expectancies will provide information on the health status of Canadian cities. (see table II)

The difference between the average of the CMA life expectancies and the rest of Canada (excluding CMAs) is +0.5 years for males and +0.6 years for females. The difference between the CMA average and Canada is +0.1 years for males and +0.2 years for females. The latter comparison corresponds to a male average CMA life expectancy (1976) of 78.0 years
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Table II: Life Expectancy at Birth by Sex, CMAs, Rest of Canada, Canada, 1976

CMA	MALE	FEMALE	DIFFERENCE	SUM
		Atlantic Ocean		
1. St. Johns,	69.7	77.0	7.3	146.7
2. Halifax,	70.1	77.7	7.6	147.8
3. Saint John,	68.7	76.3	7.6	145.0
		Province of Quebec		
4. Chicoutimi,	68.7	75.0	6.3	143.8
5. Quebec,	68.9	77.7	8.8	146.6
6. Montreal,	69.4	76.6	7.1	146.0
		Province of Ontario		
7. Ottawa-Hull,	69.8	77.9	8.1	147.7
8. Oshawa	70.8	79.4	8.6	150.2
9. Toronto	72.1	78.8	6.7	150.9
10. Hamilton	71.0	78.7	7.7	149.7
11. St. Catherines	70.3	77.7	7.4	148.0
12. Kitchener-Wat.	72.0	79.1	7.0	151.1
13. London	71.1	78.6	7.5	149.7
14. Windsor	70.5	77.1	6.6	147.6
15. Sudbury	69.7	76.8	7.1	146.5
16. Thunder Bay	68.5*	76.8	8.3	145.3
		Prairie Region		
17. Winnepeg	71.1	78.2	7.1	149.3
18. Regina	71.0	79.3	8.3	150.2
19. Saskatoon	70.2	78.6	8.4	148.8
20. Calgary	71.4	78.2	6.8	149.6
21. Edmonton	71.2	79.6	8.4	150.8
		Pacific Region		
22. Vancouver	71.6	79.0	7.3	150.6
23. Victoria	74.7	81.0	6.3	155.7
Rest of Canada	70.0	77.4	7.5	147.4
Canada	70.4	77.8	7.4	148.2
CMA average	70.5	78.0	7.5	

NOTE: Some Figures May Not Add Due To Rounding.

compared to the Canadian average of 77.8 years. A comparison of averages reveals that the male and female CMA life expectancies are closely associated with both the Canadian values as well as the non metropolitan values. Furthermore, on average, CMA life expectancies for both sexes tend only to be slightly higher than the non-metropolitan life expectancies (a difference of approximately ½ year). Perhaps this similarity suggests that regional factors rather than level of urbanization are primarily responsible for differences in life expectancies.

The three highest male life expectancies are found in Victoria, 74.7 years, Toronto, 72.1 years, and Kitchener-Waterloo, 72.0 years. On the other hand, the three lowest values were in Thunderbay, 68.5 years, Saint John, 68.7 years, and Chicoutimi-Jonquiere, 68.7 years. Comparing the two extremes yields a difference of 6.2 years. With respect to females the three highest life expectancies are found in Victoria, 81.0 years, Edmonton, 79.6, and Oshawa, 79.4 years. The three lowest values are in Chicoutimi-Jonquiere, 75.0 years, Saint John, 76.3, and Montreal, 76.6 years. Comparing the two extremes yields a difference of 6.0 years.

For males, 11 CMAs fall below the Canadian average (70.4) and 12 CMAs fall above, while, for females, 10 CMAs fall below and 13 CMAs fall above. With respect to males, of the 23 CMAs, 13 are clustered less than one year, in both positive and negative directions, around the Canadian mean, while the remaining 12 CMAs differ from the mean by one year or more. For example, the three highest positive differences are in Victoria, 4.3 years, Toronto, 1.7 years, and

Kitchener-Waterloo, 1.6 years. The three highest negative differences occur in Thunder Bay, 1.9 years, Chicoutimi-Jonquiere, 1.7 years, and Saint John, 1.7 years.

With respect to females, of the 23 CMAs, 11 are clustered less than one years, in both directions, around the Canadian mean, while the remaining 12 CMAs differ from the mean, in both directions, by one year or more. For example, the three highest positive differences are in Victoria, 3.2 years, Edmonton, 1.8 years, and Oshawa, 1.6 years. The three highest negative values are in Chicoutimi-Jonquiere, 2.8 years, Saint John, 1.5 years, and Montreal, 1.2 years.

In general, there is a strong positive relationship (R^2=72%) between male and female life expectancies at birth among the 23 CMAs. This means that CMAs with high female life expectancies tend to have high male life expectancies or, conversely, CMAs with low female values tend to have low male values as well.

In all 23 cities, Canada/rest of Canada, female life expectancies are greater than the males'. The average CMA gap between males and females is 7.5 years, while the Canadian average is 7.4 years. No clear pattern exists between the male/female differences; high and low differences are a result of a combination of high and/or low male and/or female life expectancies.

Based on both life expectancies a general spatial relationship tends to exist. Moving from east to west across Canada, with respect to males and females, the Atlantic CMAs are below the Canadian average, the Quebec CMAs are slightly below the Atlantic CMAs, Ontario is spatially divided, the prairies are generally above the Canadian rate and British Columbia CMAs are well above the average Canadian life expectancy. More specifically, the northern CMAs in Ontario - Ottawa, Thunder Bay, Sudbury - tend to have lower male and female life expectancies while remaining CMAs in southern Ontario have values at or above the Canadian average. The dividing line is approximately 43° N latitude. Therefore, taking into account only the CMAs in Ontario, Quebec and the Atlantic Provinves, those above this latitude tend to have below average male and female life expectancies while the CMAs under this mark (all located in Southern Ontario) tend to be at or above average. This north-south differentiation is present in the prairies and British Columbia as well but the differences in most cases are very minute. The southern CMAs - Winnepeg, Regina, Calgary, Vancouver and Victoria - tend to have slightly higher life expectancies than the northern CMAs - Edmonton and Saskatoon. Even Victoria, located south of Vancouver, has a higher male life expectancy than Vancouver. For females, this north-south difference throughout Canada, in general, also exists but is somewhat weaker, especially in the prairies.

Overall, with both sexes there is a general tendency for an east-to-west pattern of change in life expectancies. Starting on the Atlantic coast the CMA values are generally below average; the overall CMA values in Quebec decline slightly. Continuing westward into Ontario; the CMA life expectancies, in general, climb above the Canadian average and continue to increase slightly in the westward direction through the prairies and finally, British Columbia where the expectancies are highest. By

Table III: Average Life Expectancy at Birth by Sex, CMA/Regional, Rest of Canada, Canada, 1976

CMA REGION	MALE	FEMALE	SUM (male+female)
ATLANTIC	69.5	77.0	146.5
QUEBEC	69.0	76.4	145.5
ONTARIO	70.6	78.1	148.7
PRAIRIES	71.0	78.8	149.7
PACIFIC	73.2	80.0	153.2
REST OF CANADA	70.0	77.4	147.4
CANADA	70.4	77.8	148.2

NOTE: Some Figures May Not Add Due To Rounding.

summing the average male/female CMA life expectancies on a regional basis the same pattern is evident. (Table III)

In closing the section of life expectancies at birth among the CMAs, it is worthwhile to make the following observations:

i) the dominance of Victoria, B.C. for both male and female life expectancies at birth.

ii) the below average life expectancies for the Atlantic, Quebec and Northern Ontario CMAs

iii) the fact that all CMAs with above average life expectancies are within close proximity of the Canada-U.S. border.

4.3 Part B - Standardization Process

Whereas life expectancies provide an overall general measure of mortality the group standardized mortality rates provide greater specificity and mortality information. By aggregating certain ages on the basis of relevant life cycle groups and by calculating the respective mortality rates of each group the reasons for overall excessively high or low mortality rates can be pinpointed by the weaknesses or strengths within the aggregated age groups. Thus, instead of analyzing 19 age groups from the life table, (0,1,5,10,...85+), the aggregated approach provides the same information in only 5 age groups. The following age categories and titles have been created:

AGE 0 - Newborns - this age group was not aggregated with other ages because alone it is an indicator of infant mortality.

AGE 1-14 - Young children - this group is composed of infants (pre-school) and young children (elementary school)

AGE 15-24 - Young Adults - generally, the secondary and post secondary

AGE 15-24 (continued) - education population.

AGE 25-64 - Mature Adults - working class population.

AGE 65-85+ - Old Adults - retired, senior citizen population.

TOTAL - mortality index of entire age group (0-85+).

The standardized mortality rates were calculated as follows*:

$$\hat{M}_0^{s,i} = M_o^{s,i} \quad \text{(age 0)}$$

$$\hat{M}_1^{s,i} = \frac{\sum_{x=1}^{14} L_x^{fn} M_x^{s,i}}{\sum_{x=1}^{14} L_x^{fn}} \quad \text{(age 1-14)}$$

$$\hat{M}_{15}^{s,i} = \frac{\sum_{x=15}^{24} L_x^{fn} M_x^{s,i}}{\sum_{x=15}^{24} L_x^{fn}} \quad \text{(age 15-24)}$$

$$\hat{M}_{25}^{s,i} = \frac{\sum_{x=25}^{64} L_x^{fn} M_x^{s,i}}{\sum_{x=25}^{64} L_x^{fn}} \quad \text{(age 25-64)}$$

$$\hat{M}_{65}^{s,i} = \frac{\sum_{x=65}^{85+} L_x^{fn} M_x^{s,i}}{\sum_{x=65}^{85+} L_x^{fn}} \quad \text{(age 65-85+)}$$

$$\hat{M}_{TOTAL} = \frac{\sum_{x=0}^{85+} L_x^{fn} M_x^{s,i}}{\sum_{x=0}^{85+} L_x^{fn}} \quad \text{(age 0-85+)}$$

where $\hat{M}$=standarized mortality rate
s=male or female
i=1,...25 regions
x=initial age in interval (0,1,5,10,...85)
M=same as MM(x)
L^{fn}=LL(x) in female national life table

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* For a complete summary of male and female standardized mortality results see Appendix A.

The age classifications provide the basis for convenient mortality comparisons between the sexes and among the CMAs. The main purpose is to identify the unusual or extreme standardized rates within the age categories and recognize significant relationships.

4.4 CMA Standardized Mortality Rate Study

(i) AGE 0

Infant mortality is a general indicator of a region's welfare. Whipple (1923) stated that infant mortality rates have long been regarded as the "most sensitive index of social welfare and of sanitary improvements which we possess." In 1976 the national female infant mortality rate was 117.7 female infant deaths per 10,000 live female births. The highest rates were observed in Windsor, 182.0, Saint John,137.5, and St. Catherines,136.0. The lowest rates were recorded in Victoria,60.6, Thunder Bay,62.0, and Hamilton,80.0. For males the national rate was 149.0 male infant deaths per 10,000 males born. The highest rates were recorded in Calgary,192.3, and Edmonton, 185.6, and the lowest in Victoria,90.7, London,103.8, and Toronto,119.9.

The Windsor rate for males, like females, was significantly above the national average. It is interesting to note that Windsor is the only CMA for which the female infant mortality rate is significantly greater than the male rate (182.4 for females, 160.7 for males). The only other CMA to have a higher female than male rate was Regina, however, the difference was very small. Generally, for both males and females, there is little variation in CMA rates especially when the two extreme rates are excluded. In the Western regions a marked male contrast is evident. Calgary, Edmonton, and Winnipeg have the three highest male rates; however, for females, the rates are at or below average. A notable exception in the Western region is Victoria which ranks as most favourable for both sexes in terms in infant mortality.

(ii) <u>AGE 1-14</u>

This index, in comparison to the other age intervals, consists of the lowest number of observed deaths for both males and females, and,thus, does not direct a strong influence on the total standardized rates for each CMA. As discussed earlier (3.1) this is due to the low mortality risk ~~at-risk population~~ within the age group. For females, the national rate was 3.8; the highest rates were recorded in Saint John,9.4, and Victoria,5.2, while the lowest rates were in Oshawa,0.0, Windsor,1.8, and Winnipeg,1.9. In general, there was very little variation among the CMAs. With exception to the extreme values, Saint John,N.B., and Oshawa, the remaining cities were mainly below or slightly above the Canadian average with no identifiable spatial patterns.

For males the Canadian rate was 5.5 per 10,000 males; the highest rates were in Saskatoon,9.0, and Chicoutimi,8.3, and the lowest in Oshawa, 2.2, and St. Catherines and Victoria, both 2.7. The male rates were generally higher than the female rates among the CMAs with the only notable exceptions being Saint John and Victoria.

(iii) <u>AGE 15-24</u>

For females the national rate was 5.1 per 10,000; the highest recorded in Regina 6.5 and Quebec, Edmonton, both 5.8. Note that these extreme positive values are not significantly greater than the Canadian rate. The lowest rates were recorded in Oshawa,1.5 and Saskatoon,2.2. Overall, the Maritime and Quebec CMAs are at the average, Ontario's CMAs are all below, while the Western CMAs were generally below the Canadian average. Unlike the 1-14 age group where the male and female rates were fairly similar in magnitude, the male rates in the 15-24 group are now significantly higher than the female rates. The 15-24 female rates have only increased slightly among the CMAs from the 1-14 group.

With respect to males, the Canadian rate was 15.8 per 10,000. The highest mortality rates occured in Chicoutimi-Jonquiere,16.8 and Saint John, N.B., 16.6, and the lowest in St. John's Nfld. 8.5 and Toronto,9.3. The majority of the CMAs were below the Canadian rate indicating that the non CMA areas have higher mortality rates for the 15-24 age group. This is confirmed by a non-metropolitan rate of 20.3. With the exception of Chicoutimi and Saint John, all remaining CMAs are generally below the Canadian rate especially Toronto and St. John's.

(iv) AGE 25-64

The national rate for females is 34.8 per 10,000. The highest rates occured in Chicoutimi 43.7 and Sudbury 43.4, while the lowest mortality rates were in Kitchener 28.1 and London 29.0. There is a trend towards higher mortality rates in the Maritime and Quebec CMAs, generally mixed in Ontario with the northern CMAs, Sudbury and Thunder Bay high, and the prairies and the west low.

For males, the national rate was 70.8 with the highest mortality rate in Chicoutimi,91.5, and Saint John N.B.,89.7 while the lowest rates were in Victoria,49.2 and St. Catherines,61.3. Like the females, the male rates were significantly high in Sudbury and Thunderbay. In addition, the Maritime and Quebec CMAs, including Ottawa, were generally at or above average while the remaining Ontario, Prairie and Western CMAs were at or below average. Within this age range, the male mortality rates tended to be about 2.0 times greater than females.

(v) <u>AGE 65-85+</u>

For females the national mortality rate was 546.4 per 10,000. The highest rates occured in Chicoutimi-Jonquiere,775.6, Montreal,614.6, and St. John's,600.3, while the lowest rates occured in Victoria,419.0 and Edmonton,457.5. For males, the national rate was 827.1. The highest rates were in St. John's,986.2,Thunder Bay, 978.7 and St. Catherines,946.1 while the lowest rates were recorded in Victoria, 676.9 and Kitchener,716.3. A comparison between the CMAs and national rates for both sexes indicates that male mortality is generally 1.5+ times greater than female mortality in the 65-85+ age group.

(vi) <u>TOTAL</u>

The national female rate for all age groups combined was 128.3 per 10,000, and the national male rate was 203.6. For females, Chicoutimi,178.2, Montreal,143.7, and St. John's,139.9 had the highest mortality rates overall while Victoria,99.9, Edmonton,108.5, and Regina, 112.3,had the lowest rates. For males the highest rates occured in Thunder Bay 241.0 and St. John's,238.2, and the lowest were in Victoria, 161.6 and Kitchener,176.6. For both sexes the pattern is quite similar. The Maritime and Quebec CMAs were generally above average mortality.

Table 1V: <u>Total</u> Mortality Rates of the Five Highest/Lowest Populated CMAs*

		MALES		FEMALES	
	Canada (1976)	203.6		128.3	
(1)	Toronto	193.4	[5]	119.4	[5]
(2)	Montreal	224.2	[19]	143.7	[22]
(3)	Vancouver	190.4	[4]	117.2	[4]
(4)	Ottawa-Hull	229.2	[21]	129.9	[15]
(5)	Edmonton	187.0	[3]	108.5	[2]
(23)	Saint John	212.5	[15]	133.9	[18]
(22)	Thunder Bay	241.0	[23]	139.8	[20]
(21)	Chicoutimi	212.1	[14]	178.2	[23]
(20)	Saskatoon	216.8	[18]	121.3	[7]
(19)	Oshawa	215.8	[16]	123.7	[10]

* mortality rates per 10,000
round brackets ( ) indicate CMA population rank ie: 1=highest, 23=lowest
square brackers [ ] indicate CMA <u>Total</u> mortality rank

ie: 1=lowest total mortality
23=highest total mortality

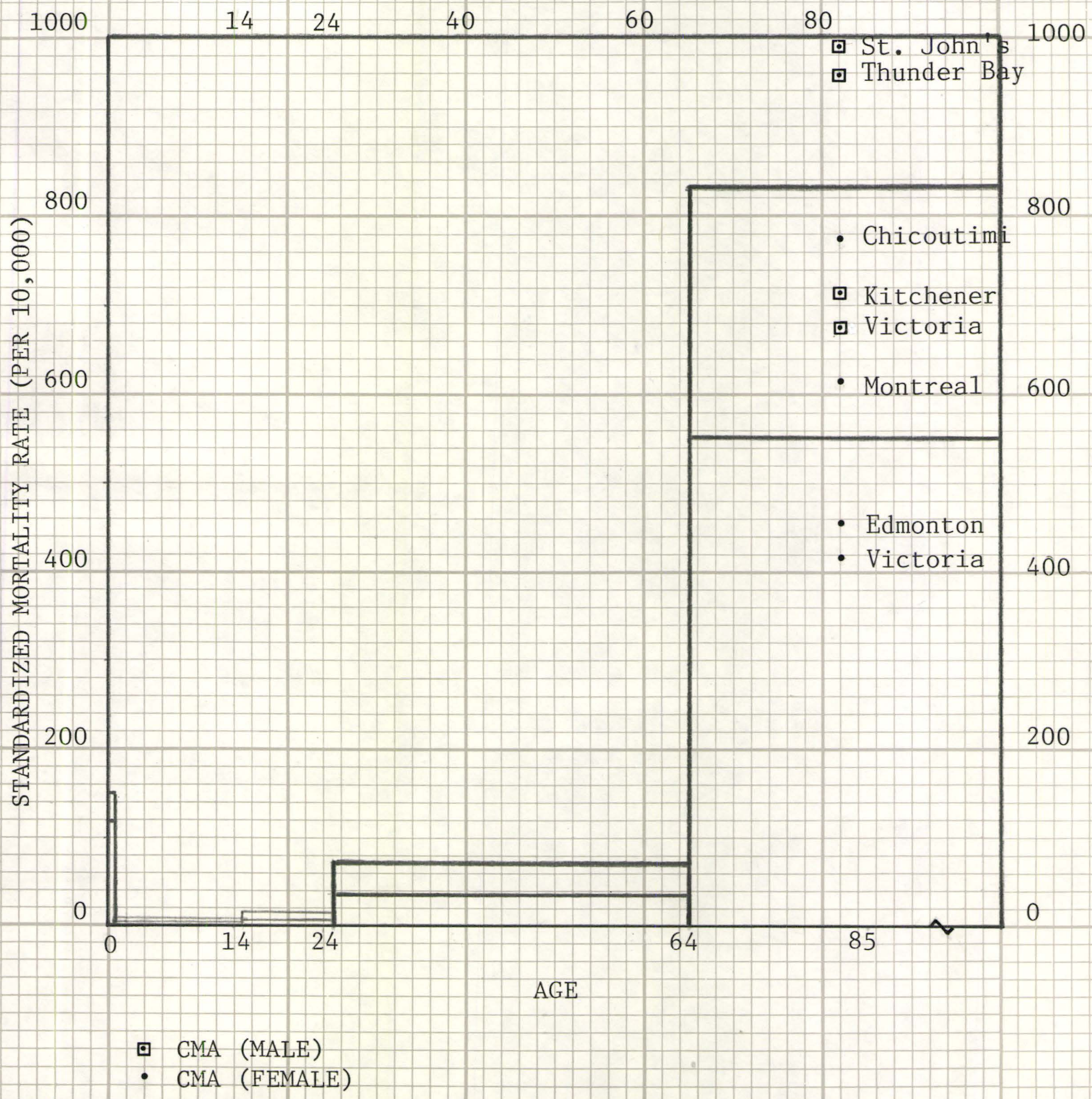
Ontario CMAs are above and below average - the northern CMAs are above average and the remaining southern CMAs are at or below average - while the prairie and west coast CMA mortality rates are generally low. Again, this east-west mortality dichotomy is evident.

As Field (1976) has noted, the variation in the population size in the urban category as an explanatory variable provides only a crude measure of any differentiation in mortality risks that might exist within the urban hierarchy between the larger and smaller sized CMAs. In comparing the five highest and lowest populated 1976 CMAs with respect to a mortality ranking only slightly do the lower populated CMAs have mortality rates above the higher populated CMAs (Table 1V). For both sexes, however, the highest mortality rate was found in the lowest populated group.

4.5 Male Versus Female Mortality

Based on the 1976 national average, the standardized male mortality rates exceeded the standardized female mortality rates throughout the entire 0-85+ age range. This is reflected by the CMA rates as well, as male rates were higher than female rates comparable to the overall Canadian rate. Figure 2. depicts the mortality step function for both sexes. At age 0, male and female rates tended to be high in comparison to the 1-14, 15-24 and 25-64 intervals. Higher rates at age 0 are generally expected due to infant mortality. Between 1-14 years, rates for both sexes, especially males, decreased at a steep rate. Males were slightly above females (a difference of only 1 death per 10,000). This age interval contained the lowest mortality rates.

FIGURE 2.
CANADA'S MALE, FEMALE STANDARDIZED MORTALITY RATE BY AGE,
± EXTREME CMA RATES, 1976

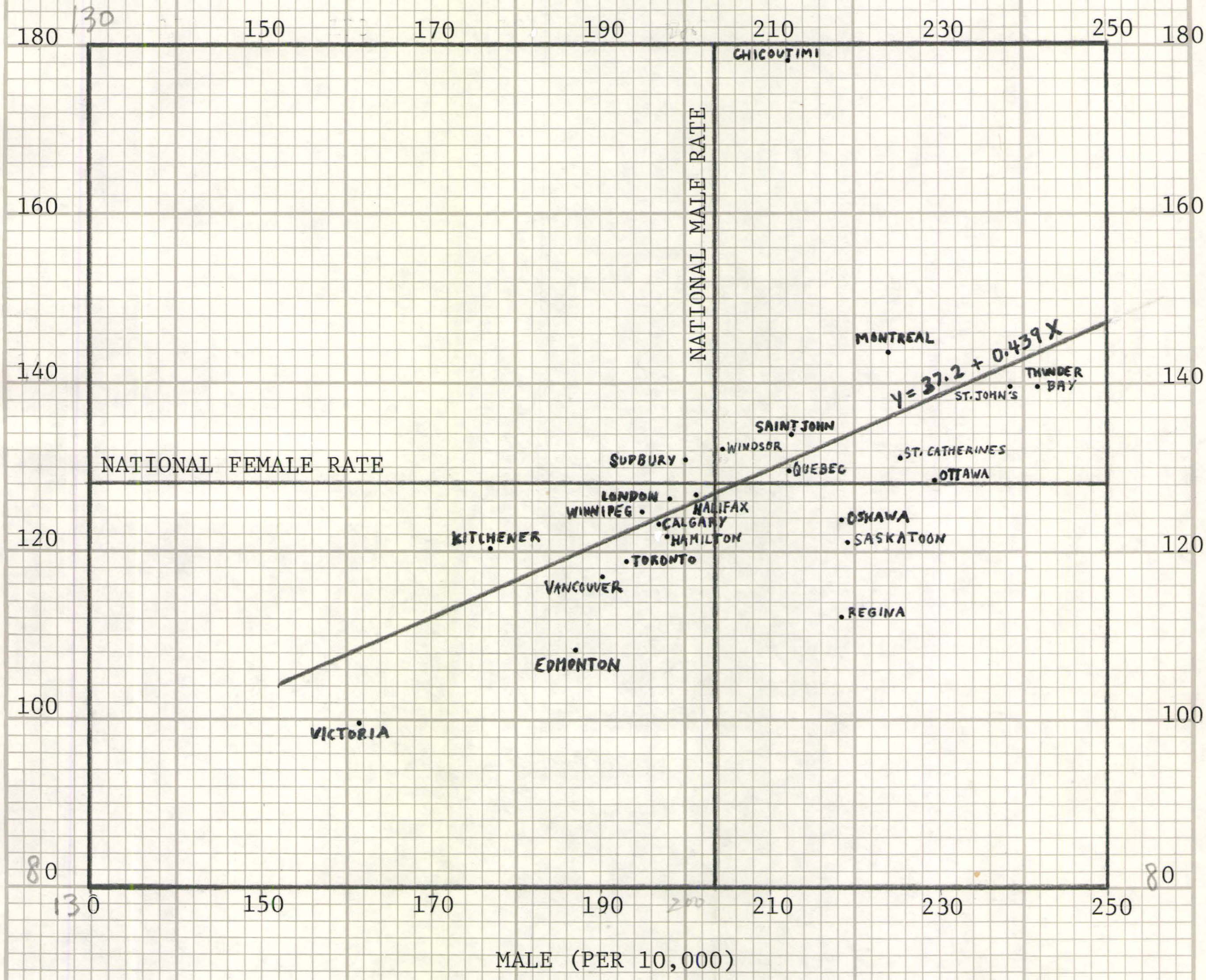


Between 15-24 years the male/female gap widened slightly, as the male rate increased more than the female rate. The female rate remained almost identical to its previous rate (an increase of 1 death per 10,000). Between 25-64 the gap continued to widen as the male rate increased at a faster rate than the female rate. Betweem 65-85+, the mortality for both sexes climbed at the steepest rate as compared to the gradual increases from the three previous age intervals. The fact that the male rate is much higher than the female rate indicates that the 65-85+ age range is more favourable for females in terms of increased life expectancies.

Differential mortality based on sex has been common in Canada as well as in other countries. In 1931 the male/female difference in life expectancy was 2.1 years, but by 1976 the difference was 7.3 years; Canada has one of the largest life expectancy differences by sex of any country (Ableson et. al.,1983). Several general reasons have been put forth to explain the higher male mortality and lower female mortality rates. According to Overbeek (1980), mortality affects males more than females because men have greater occupational hazards and there is greater pressure on men to achieve in their work. Meanwhile, women tend to be superior in resisting infections while their reduced susceptibility to degenerative diseases has also been noted. Perhaps this is because females are more willing to receive medical treatment than men. In addition, women release and express their emotions more easily as compared to men, which, in turn, contributes to greater mental health.

To view the male and female mortality rates from a somewhat

FIGURE 3.
TOTAL Standardized Mortality Rate (0-85+) Male vs. Female, CMAs, Canada, 1976



different perspective the Total male mortality rate (independent) was plotted against the Total female mortality rate (dependent) for the 23 CMAs. The result summarizes the mortality variation among the CMAs as a combined sex index (Figure 3.). The intersection of the national male and female mortality rate divides the graph into quadrants. Of the 23 CMAs, 10 fall into the quadrant 'below the national female rate and below the national male rate,' and 8 fall into the quadrant 'above the national male and female rate'. A best fit regression line forms the major axis along which these 18 CMAs are generally located - (R^2=30.8%). Identifying extremes, for both sexes Victoria and Edmonton have the most favourable mortality probabilities while Chicoutimi, Montreal, St. John's and Thunder Bay have the least favourable mortality probabilities. Chicoutimi is a very unusual case because of its higher above average female rate as compared to the above average male rate. As a result the Chicoutimi value deviates the most from the best fit regresstion line. On the other hand, only 4 CMAs are located within the two remaining quadrants. Sudbury is the only CMA to have an above average female and below average male mortality rate. The remaining three cities, Saskatoon, Regina, and Oshawa, are the only CMAs to have above average male and below average female mortality rates. Overall, Southern Ontario and Western/Pacific CMAs (Victoria, Vancouver, Edmonton, Calgary, Winnipeg) are located within the below average male and female quadrant while Northern Ontario, Quebec and Atlantic CMAs are located within the above average male and female quadrant. This general pattern is similar to the one identified earlier dealing with life expectancies at birth.

5. INTERPRETATIONS

5.1 Explanation of Differential Mortality

Thus far, based on evidence presented, differential mortality has been identified among the CMAs in terms of age and sex. This level of comparison, in turn, has provided an overall spatial mortality variation among the CMAs. Now, with reference to relevant studies and other sources this subsection will attempt to link the observed extreme CMA mortality variations to actual explanation. In several cases hypothetical reasons will be offered in order to shed light on the direct/indirect mechanisms that induce extreme mortality rates within specific CMAs.

In 1976 Victoria had the lowest standardized total mortality rates for both males and females among the 25 regions studied, thus, making it the most favoured amongst the CMAs in terms of mortality probabilities. Specifically, for both sexes, mortality rates were the lowest or extremely low for newborns (age 0), young adults (15-24), mature adults (25-64), and especially old adults (65-85+). The low mortality rate of the 'senior citizen' population is related to Victoria being the foremost retirement centre in Canada (Field, 1976); in 1976 Victoria had the highest old age dependency ratio, 23.9%, among the CMAs.*

According to Health and Welfare Canada (1984), in a study of urban mortality between 1973-1979, Victoria had significantly low mortality rates for both sexes due to coronary heart disease. In 1976 this disease was the leading cause of death for males and females age

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*represents the population age 65 and over as a proportion of persons aged 15-64

65-85+ in Canada, accounting for 36% of all male deaths and 35% of all female deaths (Statistics Canada, 1978). In addition, in a study on cancer mortality from 1973-1979, Health and Welfare Canada (1980) concluded that Victoria's male and female populations had significantly low cancer-specific mortality rates. No doubt, the low rates of these causes partly explain the favourable mortality among mature adults. Other more underlying reasons could be related to Victoria's occupational structure. Major industries include shipbuilding, sawmilling, fish, canning, and the manufacture of paper. Perhaps occupational hazards, such as the exposure to dangerous dusts and fumes are less common in Victoria's occupational framework. Due to the high concentration of an old age population not exposed to occupational risks, proper lifestyle habits and utilization of efficient health care facilities should also be noted as significant factors. Victoria's mild climate, lack of seasonal variation, especially the lack of heavy snowfall, and low pollution levels have been cited as contributing to fewer respiratory and circulatory related deaths as well as improved mental health capacities (Kevan and Champman 1980, Fields 1976).

In 1976 Edmonton had the second most favourable Total mortality probability among the 23 CMAs for females and third most favourable probability for males. Both sexes had extremely low mortality figures in the 25-64 and 65-85+ age groups. In terms of population growth, Edmonton grew rapidly between 1971-1976 possibly the result of the continued attraction of young adult migrants to a favourable economic climate generated by a strong oil and gas industry. In addition, between 1971-1976, Calgary grew rapidly and Ottawa-Hull, Victoria, Kitchener and Oshawa also experienced substantial growth in population (Mitchell et. al., 1980). With the exception of Ottawa, the high growth CMAs had significantly low mortality rates in the 25-64 working-age bracket. Perhaps this is an indication that incoming migrants, especially those looking for employment, are in good general health; thus, their increased presence lowers the corresponding death rates in their respective age group. This attraction of generally young working-age people to Edmonton's robust economy is evident by the fact that Edmonton had one of the lowest old age dependency ratio's (9.5%) among the CMAs in 1976 (Ibid). Comparing Edmonton to Victoria provides an interesting contrast. Victoria is a retirement centre that attracts a senior citizen population; Edmonton, on the other hand, primarily between 1971-1976, was a thriving economic centre attracting a young employment-searching population. On the other hand, very slow growth or declining cities such as Windsor and Sudbury, had high mortality rates for both sexes in the 25-64 age group. Therefore, with respect to the working population; high growth is perhaps synonymous with improved occupational health standards, increased medical facilities and higher personal incomes. These factors in turn, may contribute to a decline in premature mortality rates in the 25-64 age group. In fact, mortality rates have been shown to vary by income level in Canada - high income populations have tended to experience significantly lower mortality rates than low income populations (Health and Welfare Canada, 1980b).

In the three Quebec CMAs the mortality rates were above average or very high for males and especially for females. Specifically, Chicoutimi-Jonquiere had the highest level among the CMAs for both sexes between the age 25-64. All cause-specific Health and Welfare studies have identified the Quebec CMAs, especially Chicoutimi, as having significantly high mortality rates associated with cancers and heart ailments (Health and Welfare Canada 1980, 1980a, and 1984). Between 1973-1979 males and females had significantly elevated mortality rates due to coronary heart disease (Health and Welfare Canada, 1984). In 1976 this cause of death accounted for 36% of all male deaths and 17% of all female deaths between the ages 35-64 (Statistics Canada, 1978). Lung cancer, which accounted for 9% of all male deaths between the age 45-64 in 1976, was significantly high in Chicoutimi, as was mortality due to chronic obstructive lung disease for females between 1973-1979 (Statistics Canada 1980, Health and Welfare Canada 1984). Similarily, Quebec and Montreal had significantly high mortality rates for several of the same causes observed in Chicoutimi. One uncommon cause among the three tended to be a very high rate of mortality among women due to breast cancer in Montreal; in 1976 this was the leading cause of death among females, 35-54. Because of a high rate of mortality within the mature or working population, this group may be characterized by risk factors related to their industry capable of producing occupational health hazards (Ableson _et. al.,_ 1983). According to a Labour Canada (1984) publication entitled, "Employment Injuries and Occupational Illnesses", in 1976 1,058 fatalities in Canadian industry were recorded. Occupational related deaths were unavailable at the CMA level, however, of 932 Compensations claims made for fatal occupational injuries and illnesses at the provincial level, the highest number (241) were recorded in the province of Quebec (Statistics Canada, 1978).

Because of high cancer rates within Quebec (region), perhaps occupations common among Quebec's CMAs are associated with an excess risk of cancer. According to Cole and Goldman (1975), carcinogens such as asbestos, vinyl chloride, and benzene pose major hazards to the exposed work force. They have noted a link between increased exposure to several carcinogens and lung cancer. Most notably, the high risk occupations associated with high lung cancer mortality include coal, nickel and asbestos miners/users. Basavarajappa and Lindsay (1976) have observed that the mortality risks in the coal mining area of the Atlantic region tended to be quite inflated for both sexes suggesting the more general hazards than those tied specifically to occupation at play. The high mortality rate for the 25-64 male population in Sudbury can, likewise, be related to occupational and non-occupational exposure. Sudbury is a rich mining area where industries are mainly associated with mining, particularly nickel smelting and refining. As a result, Sudbury is exposed to high levels of the carcinogen nickel, which Cole and Goldman (1975) have noted as a (lung) cancer causing agent. Sudbury males did in fact have a significantly high lung cancer mortality rate according to Health and Welfare Canada (1984) in studies between 1973-1979. Similarily, in the province of Quebec, asbestos mining may provide the reasons for the region's high death rates of lung cancer and other respiratory ailments. In addition, the use of asbestos in shipbuilding may also explain the high cancer related death rates, especially lung cancer, in the Atlantic CMAs where manufacturing is generally based on fishing equipment and marine engines (Cole and Goldman 1975, Health and Welfare Canada 1984, and Statistics Canada 1978). Thunder Bay, a northern Ontario CMA, which has the highest Total mortality rate among males, also deals with shipbuilding and repair, however Health and Welfare Canada (1984) detected low lung and other cancer related death rates. Such inconsistencies require the need for further cause-related examination.

Indirect hazardous exposures such as water and air pollution, have detrimental effects on the population as well. According to Mitchell et. al.,(1980) several constituent municipalities in various urban areas dumped waste water directly into nearby rivers and oceans, with only a screening to remove solids. This problem was most serious in all urban areas of the Atlantic provinces and Quebec where few municipalities had sewage treatment plants. In a further study which examined sewage samples of various Ontario municipalities Windsor was found to contain the highest concentrations of PCBs (Civic Public Works, 1979). Over the period 1974 to 1976 Windsor, (in the direct line of the prevailing winds from Detroit), also had the highest sulphur dioxide level among urban areas in Canada. Perhaps Windsor's high infant mortality rate is somehow related to its poor air and water quality. According to Health and Welfare Canada (1984), Windsor, during the seven year study, was found to have a significantly high infant mortality rate.

5.2 Explanatory Variables

To further explore mortality rate differences, data pertaining to socio-economic indicators were collected at the CMA level in order to study the effects of specific explanatory variables on mortality. A total of 15 variables were chosen which included measures of health facilities/resources, education, income, industrial index, crime, traffic deaths and homicides.* All variables were correlated against the male and female mortality data to establish the association between the dependent variable (mortality) and all explanatory variables. Only the higher correlated variables with the "right" sign were chosen for closer analysis. As a result, the effects of a few specific variables on mortality rather than the inclusion of several insignificant variables variables was of greater importance. A multiple regression procedure using the STEPWISE method was employed to try and establish relationships between the chosen variables and CMA mortality among the different age indexes. In the STEPWISE method the explanatory variables are examined at each step for entry or removal. Due to restrictions that will be discussed shortly, the criterion for entry and for removal were made less stringent. The F-to-enter probability was set at 0.98 and the F-to-remove probability was set at 0.99. Despite relaxing the standards, only one variable, health cost per capita, indicated a significant effect on mortality. This variable showed significance among females, 1-14, and males, 25-64 (results are reported in Table V).

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* For all variables and sources see Appendix B

Table V: Results of Regression Analysis - significant T value, t-ratios,* R^2

DEPENDENT VARIABLE (mortality rates)		INDEPENDENT VARIABLE	SIG. T 1.	2.	3.
Females,	age 0	Health cost	.097	.501	
		Population per doctor	.768	.768	
		R^2	.125	.129	
	age 1-14	Health cost	.001(-3.69)	.233	
		Population per doctor	.350	.350	
		R^2	.393	.420	
	age 15-24	Number of doctors	.111	.283	
		Health cost	.705	.705	
		R^2	.116	.123	
	age 25-64	University education	.076	.081	.178
		Health cost	.131	.131	.214
		Income	.343	.625	.625
		R^2	.143	.237	.247
	age 65-85+	Income	.098	.188	
		Health cost	.447	.447	
		R^2	.125	.151	
	TOTAL	Income	.080	.172	
		Health cost	.347	.347	
		R^2	.139	.177	
Males,	age 0	No. of hospital beds	.222		
		R^2	.070		
	age 1-14	Health cost	.256	.505	
		Number of doctors	.668	.668	
		R^2	.061	.070	
	age 15-24	Health cost	.154	.178	.398
		No. of hospital beds	.241	.241	.254
		Pop. per doctor	.867	.883	.883
		R^2	.094	.156	.158
	age 25-64	Health cost	.009(-2.90)	.003(-3.32)	.0058(-3.11)
		Pop. per doctor	.066	.066	.084
		University education	.263	.324	.324
		R^2	.286	.399	.430
	age 65-85+	Health cost	.333		
		R^2	.045		
	TOTAL	Health cost	.122	.168	
		Population per doctor	.514	.514	
		R^2	.110	.129	

* t-ratios, in parentheses, greater than 3.0 in magnitude are significantly related to the dependent variable

For females, 1-14, when entered on step 1. health cost per capita was significant, having the highest explanatory power of any single variable (R^2=.393). In step 2., however, the inclusion of the population per doctor variable lowered the significance of the health cost per capita variable to a non significant level. The second variable entered caused the R^2 to increase from .393 to .420. For males, 25-64, health cost per capita was significant at two of the three steps. With the inclusion of population per doctor the significance of health cost per capita was increased, as was the R^2, from .286 to .399. The variable population per doctor was not significant. In step 2., with the inclusion of population per doctor the significance of health cost per capita was increased as was the R^2, from .286 to .399. The variable, population per doctor, however, was not significant. In step 3., the inclusion of university education slightly decreased the still significant health cost per capita variable and population per doctor. The variable, university education, was not significant but it raised the R^2 from .399 to .430. In both male and female examples, where variable health cost per capita was significant, the sign of the t-ratio was as expected. A negative sign indicates an inverse relationship with mortality.

Based on the significant variable, health cost per capita, the results indicate that health costs have a more favourable mortality effect on females than males, age 1-14; and that the effect is more significant for males than females, age 25-64. The latter relationship may be explained as follows; males 25-64, pay higher health care expenditures; in turn, helping to efficiently control work related illnesses or injuries that would otherwise, if left untreated, lead to death.

Overall, the disappointing results of this analysis can be blamed on two related problems. First, other variables than the 15 collected contribute significant effects on mortality. Lifestyle, (including socio-economic status), environment, human biology and health care organization are the basic factors that influence health status (Ableson, et. al., 1983). However, the complex interactions among these factors limits the degree to which mortality can be explained. Obviously, there is a need for further research to concentrate on collecting a wider range of reliable variables that encompass the four general factors mentioned above. Such an extreme list of explanatory factors could then be used as mortality indicators or predictors. The second problem, specifically a restriction, relates to the data collection. Several variables were originally obtained from the provincial scale and used as surrogate CMA values simply because the relevant data was unavailable at the CMA level. Innes (1980) performed a similar task with multiple regression and 28 explanatory variables from the provincial scale. His analysis revealed no significant relationships; he concluded that causative relationships could not be expected to show up at the provincial level. No doubt, variables specific to the CMAs would enhance the levels of explanatory significance. In this analysis health costs were obtained from the provinces but showed some statistical significance and a consistent "right" sign of the t-ratio. This demonstrates the influential effect that health costs has on health status. Still there is urgent need for data, otherwise unavailable or unrecorded, specific to the CMA in order to obtain greater understanding of the mechanisms influencing significant variations among CMA mortality rates.

6. Conclusions

This study has provided an in-depth investigation of mortality rates among Canada's 23 CMAs. Using a demographic approach,LIFE TABLES were constructed with the 1976 data provided. From a general (life expectancies) and specific (standardized mortality) level of analysis the mortality rates were examined across the CMAs. Both mortality measures revealed the same general spatial pattern: for both sexes, Atlantic, Quebec and Northern Ontario CMAs (including Ottawa which belongs partly to the province of Quebec) had mortality rates below the Canadian mean, however, Southern Ontario, and Western CMAs, especially Victoria, had mortality rates generally at or below the Canadian mean. In terms of direction, there tended to be an east to west decrease in mortality rates across Canada and a north to south decrease in mortality rates especially in Eastern Canada. The analysis of the standardized rates revealed that Victoria, Edmonton and Kitchener had the most favourable mortality rates for males and females; Thunder Bay, St. John's Montreal and Chicoutimi, on the other hand, had the least favourable mortality rates for males and females. A comparison between males and females depicted male rates higher than female rates especially in the 65-85+ and 25-64 age groups. Male and female rates also indicated a strong positive relationship.

The weak statistical results indicate a need for further research into the effects of certain variables on mortality. In addition, an increase in the data base at the CMA level is essential. Only then can a link be established between observation and explanation with respect to mortality rates.

List of References

Ableson, J.P Paddon and C. Strohmenger. 1983. Perspectives on Health Catalogue 82-540E (Occasional), Ottawa.

Barrett, F. A. (Ed.) 1980. Canadian Studies in Medical Geography Geographical Monographs, no. 8, Toronto.

Basavarajappa , K. S. and J. Lindsay. 1976. Mortality Differences in Canada 1960-62 and 1970-72 Statistics Canada, Health Division, Vital Statistics Section, Ottawa.

Canada, Labour Canada. 1984. "Fatalities in Canadian Industry by Occupation, Canada, 1972-1981" in Employment Injuries and Occupational Illnesses Ottawa.

Civic Public Works. 1979. "PCB's in Municipal Sewage" in F. A. Barrett (ed.) Canadian Studies in Medical Geography Geographical Monographs, no.8, Toronto.

Cole, P. and M. B. Goldman. 1975. "Occupation" In J. F. Fraumeni, Jr., (Ed.) Persons at High Risk of Cancer Academic Press, New York.

Field, N. C. 1976. "Temporal Trends and Spatial Patterns of Mortality in Canada" In F. A. Barrett (Ed.) Canadian Studies in Medical Geography Geographical Monographs, no. 8, Toronto.

Health and Welfare Canada. 1980. Mortality Atlas of Canada, Vol. 1 Cancer Mortality Health Division and Statistics Canada.

_________________________. 1980a. Mortality Atlas of Canada, Vol. 2 General Mortality Health Division and Statistics Canada.

_________________________. 1980b. Mortality By Income Level in Urban Canada Health Division and Statistics Canada.

_________________________. 1984. Mortality Atlas of Canada, Vol. 3 Urban Mortality Health Division and Statistics Canada.

Innes, F. C. 1980. "A Preliminary Investigation at Two Scales in Ontario" In F. A. Barrett (Ed.) Canadian Studies in Medical Geography Geographical Monographs, no. 8, Toronto.

Johnston, R. J. (Ed.) 1981. The Dictionary of Human Geography Blackwell Reference, Oxford.

Kevan, S. M. and R. H. Chapman. 1976. "Variations in Monthly Death Rates in Canada: A Preliminary Investigation" in F. A. Barrett (Ed.) Canadian Studies in Medical Geography Geographical Monographs, no. 8, Toronto.

Keyfitz, N. and W. Flieger. 1968. World Population - An Analysis of Vital Data University of Chicago Press, Chicago.

______________________ . 1971. Population - Facts and Methods of of Demography W. H. Freeman and Company, San Francisco.

Liaw, K. L. 1979. "Analysis and Projections of the Canadian Interregional Population System", Department of Geography, McMaster University, Hamilton.

Mitchell, B., W. Bond, F. Jones and N. Shulman. 1980. "Urban Profiles" Perspectives Canada III Ministry of Supply and Services, Statistics Canada, Ottawa.

Overbeek, J. 1980. Population and Canadian Society Butterworth and Co., Toronto.

Smith, T. L. and P. E. Zopf, Jr. 1970. Demography: Principles and Methods F. A. Davis Company, Philadelphia.

Statistics Canada. 1978. Canada Year Book 1978-79 Ottawa: Statistics Canada.

______________. 1980. "Quality of Data - Series I: Sources of Error-Coverage" in 1976 Census of Canada Catalogue 99-840, Ottawa.

Whipple, G. C. 1923. Vital Statistics John Wiley & Sons, Inc., New York.

APPENDICES

APPENDIX A

MALE AND FEMALES STANDARDIZED MORTALITY RESULTS, 23 CMAs, REST OF CANADA, CANADA, 1976

MALES

CMA	AGE 0	1-14	15-24	25-64	65-85	TOTAL
1	.014095	.000488	.000646	.007936	.098624	.023820
2	.016505	.000685	.001553	.007007	.081407	.020104
3	.017003	.000346	.001055	.008972	.082588	.021250
4	.017355	.000628	.001680	.009146	.081506	.021213
5	.013683	.000735	.001489	.008804	.082764	.021210
6	.012305	.000625	.001293	.007779	.091659	.022418
7	.013503	.000472	.001165	.007636	.094653	.022916
8	.016190	.000223	.001153	.006682	.090333	.021583
9	.011993	.000270	.000930	.006236	.080496	.019339
10	.014734	.000558	.000972	.006630	.081211	.019763
11	.015554	.000288	.001311	.006781	.094611	.022501
12	.016235	.000524	.001223	.006131	.071634	.017663
13	.010375	.000482	.001239	.006800	.081265	.019821
14 (Windsor)	.016066	.000395	.001135	.007154	.083429	.020467
15	.012793	.000360	.001469	.008317	.078571	.020060
16	.016911	.000353	.001463	.008638	.097869	.024100
17	.017853	.000584	.001205	.006668	.079251	.019466
18	.012039	.000520	.001341	.007139	.089492	.021661
19	.013096	.000900	.001451	.007094	.089243	.021684
20	.019231	.000298	.001500	.006341	.081330	.019724
21	.018556	.000348	.001307	.006487	.075959	.018704
22	.015510	.000441	.001087	.006617	.077588	.019038
23	.009058	.000270	.001224	.004921	.067685	.016155
24	.015795	.000644	.002030	.007205	.081824	.020326
25	.014902	.000549	.001577	.007082	.082714	.020358

FEMALES

CMA	AGE 0	1-14	15-24	25-64	65-85	TOTAL
1	.012346	.000306	.000441	.003704	.060035	.013993
2	.011899	.000373	.000451	.003718	.053336	.012677
3	.013752	.000935	.000437	.003994	.055629	.013388
4	.013357	.000294	.000521	.004369	.077563	.017820
5	.010335	.000352	.000580	.003461	.055353	.012946
6	.010592	.000357	.000467	.003922	.061461	.014372
7	.008527	.000404	.000373	.003596	.055404	.012993
8	.009560	.000000	.000153	.003247	.053589	.012305
9	.010991	.000243	.000350	.003307	.050688	.011940
10	.007967	.000268	.000498	.003214	.052672	.012238
11	.013619	.000362	.000239	.003816	.055513	.013150
12	.009576	.000395	.000331	.002811	.052632	.012056
13	.010881	.000217	.000310	.002897	.055450	.012640
14 (Windsor)	.018239	.000179	.000416	.003940	.055450	.013246
15	.010811	.000312	.000428	.004343	.056016	.013485
16	.006196	.000374	.000432	.004071	.059422	.013982
17	.010702	.000191	.000431	.003576	.053109	.012512
18	.012480	.000279	.000648	.003169	.047334	.011237
19	.012393	.000417	.000224	.003502	.051202	.012133
20	.011708	.000234	.000456	.003180	.053111	.012345
21	.009567	.000354	.000582	.003096	.045754	.010852
22	.009739	.000318	.000402	.003366	.049582	.011717
23	.006055	.000522	.000427	.002972	.041895	.009990
24	.013015	.000450	.000629	.003431	.055879	.013093
25	.011771	.000377	.000513	.003479	.054640	.012827

APPENDIX B

EXPLANATORY VARIABLES

(1)* Per capita Expenditure for Personal and other Health Care, Canada and Provinces, 1976, in dollars per capita

Source: National Health Expenditures in Canada, 1970-1979, Health Information Division, Health and Welfare Canada.

(2) 1976 Rated Bed Capacity (# of beds, cribs) by CMAs (as of January 1, 1976)

Source: List of Canadian Hospitals and Special Care Facilities, Statistics Canada, 1976 Catalogue 83-201 annual

Rated Bed Capacity = "the number of beds and cribs that a hospital has been approved to accomodate, on the basis of established standards of floor area per bed. This capacity would have been approved at the time of: original construction, or after completion of addition or other structural changes."

(3)* Total number of active civilian physicians excluding interns and residents, 1976, by Province

Source: Canada Year Book, 1980-81, Ministry of Supply and Services and Statistics Canada, 1981, p. 199

(4)* Population per physician

(5)* Rates per 100,000 population, 1976, by Province

Source: Canada Year Book 1978-79, p. 199.

(6)* Number of persons killed in traffic related accidents, 1976, by Province

Source: Crime and traffic enforcement statistics, 1976, Catalogue 85-205 Ministry of Industry, Trade and Commerce, and Statistics Canada, table 5

(7)* Number of known/reported homicides, 1976, by Province

Source: same, table 2

(8) Percentage Distribution of the Population 15 years and over, with post secondary non-university level of schooling (includes those with and without certificate or diploma), CMAs, 1976 (includes males and females)

Source: 1976 Census of Canada, Population: Demographic Characteristics - School Attendance and Level of Schooling, Volume 2, Statistics Canada, table 27 Catalogue 29-826 (Bulletin 2.7)

(9) Percentage Distribution of the Population 15 years and over, with University level of schooling* (includes those with and without certificate, diploma or degree), CMAs, 1976
* includes college level

Source: same as above, table 27

(10) Number of violent crimes* and (11) rate of violent crimes per 100,000 population, 1976, CMAs
*violent crimes include murder, attempted murder, rape, manslaughter, other sexual offenses, woundings, assaults (not indecent) and robberies

Source: Crime and traffic enforcement statistics, 1976, Statistics Canada, Catalogue 85-205 (annual), 1978, table 3

(12) Average Personal Income

Source: see Dr. Liaw

(13) High Stressor industrial activity, by urban areas
Percentage of all establishements in the high stressor group

Source: see below

(14) Percentage of all industrial workers in the high stressor type

Source: Human Activity and the Environment, Catalogue 11-509,1974, Perspectives Canada III, Ministry of Supply and Services and Statistics Canada, 1980, Ottawa, table 11.22, p. 213

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*Indicates Provincial figures