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Socio-Economic Status and its Relationship to Life Expectancy:

A Study of Urban Ontario at the Census Tract Level in 1991

By Neil Wilson B.A. (Honors)

A thesis submitted to the Faculty of Graduate Studies and Research in partial
fulfillment of the requirements for the degree of
Master of Arts

Department of Geography and Environmental Studies

Carleton University

Ottawa, Ontario

November 1999

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ACCEPTANCE SHEET

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And Research acceptance of the thesis

“Socio-Economic Status and its Relationship to Life Expectancy:
A Study of Urban Ontario at the Census Tract Level in 1991”

Submitted by Neil M. Wilson B.A. (Honors)
In partial fulfillment of the requirements for the degree of Master of Arts

Thesis Supervisor

Chair, Department of Geography and Environmental Studies

Carleton University
November 1999

Abstract

The current study investigates the relationship between socio-economic status (SES) to life expectancy at the census tract level for urban Ontario (1991). Twenty-four SES variables were tested covering such general areas as economic activity, education, occupation, housing and social dimensions of SES. The majority demonstrated that SES differentials in life expectancies are present in urban Ontario.

A secondary analysis asked whether differences in SES alone were sufficient to explain the differences in life expectancy in Ontario's 10 Census Metropolitan Areas (CMAs). The tentative conclusion is that most of the variation can be explained by a community's SES alone.

Overall, it was concluded that the phenomenon of SES mortality differentials is now well established and that additional normative or descriptive studies are not called for. Instead, what is now required are studies that, by their data and design, are able to go beyond the descriptive to answer the deeper questions of why this phenomenon exists and persists.

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CHAPTER 1 INTRODUCTION

The purpose of this paper is to explore the relationship between socio-economic status (SES) and life expectancy differentials in Ontario in 1991. The objectives of the study are three-fold:

- (1) It will test how different socio-economic variables perform when subjected to calculating life expectancy differentials when Ontario is stratified along these socio-economic dimensions.
- (2) Some of the individual variables tested will be combined into a regression model.
- (3) The data derived from the model will be used to determine whether life expectancy is simply a function of a community's SES profile, or whether place has a bearing on a community's life expectancy over and above what the socio-economic profile would have predicted.

Interest in the relationship between socio-economic status (SES) and the health of populations dates back to the 19th century; however, it was not until well into the 20th century that a substantial body of empirical knowledge started to emerge (Jerrett et al., 1998). Since the mid-1980s a goal of many governments, including

Canada's, has been "health for all by the year 2000". At the time of these announcements, it was widely accepted that socio-economic health differentials were one of the major impediments to reaching this goal. Now, with the year 2000 virtually upon us, the goal of health for all has not been met, largely because these socio-economic health inequalities persist (Wilkins et al., 1991).

After World War II, many industrialised western countries proceeded to construct large social safety nets. One of their primary functions was to ensure universal access to health care for the entire population, and in so doing eradicate any socio-economic differentials in health. It was generally felt that equality of access to the health care system would, over time, lead to equality in the health of the population. However, as the decades of universal health care passed it became increasingly clear that socio-economic health differentials persisted. Those citizens of lower SES (however defined), who were intended to be the primary beneficiaries of universal health care, continued as a group to have poorer health outcomes than their higher socio-economic compatriots.

If universal access to health care does not sufficiently address the problem of socio-economic health differentials, the pertinent question for policy makers then becomes "What strategy will give the largest health improvement from the use of limited societal resources?" In Canada, as in other jurisdictions, this area can become

problematic for policy makers. Whenever the issue of inequality in a population's health arises, government solutions are usually couched in terms of doctors, nurses, hospitals and other areas that are directly related to the health care system. It is extremely difficult for governments to propose programmes such as increased taxes on the wealthy to fund income support for those of low-income status, lower tuition for students who otherwise could not afford post-secondary education, or government funded school breakfast programmes in low-income neighbourhoods. Yet, there is mounting evidence that money spent in these and a number of other areas may do more for a population's health than would investing in the latest medical technology.

At the provincial level per capita expenditure on health is positively associated with life expectancy. The correlation becomes negative when life expectancy is correlated with health expenditures as a percentage of gross domestic product. In general, Canadian life expectancy has a gradient from east to west, gradually increasing as one moves westward. Given the negative correlation between percentage of GDP devoted to health expenditures and life expectancy it is thought that the "have-not" eastern provinces are spending a disproportionate amount of their limited resources on direct health care spending. The consequent under-funding of other, non-health care, programmes exacerbates the

lower life expectancy of the region. Furthermore, although this particular argument focuses on provincial scale life expectancy, similar arguments could apply to mortality differentials between SES groups. After all, universal health care is, by definition, universal, whereas eligibility for many other social programmes has some sort of means' test attached. By spending a large percentage of GDP on health care, governments are left with less to spend on the other, means' tested, programmes.

Before going further, it may be necessary to clarify exactly what is meant by SES status. The terms "socio-economic status", "social status", "social class" and "social stratification" have in general been put forward by sociologists, and all represent slightly different dimensions of a similar concept. For the purpose of this paper, these terms may be used interchangeably and are intended to identify much the same concept (Davey-Smith, 1990). To define that concept is, however, more difficult. Usually, a valid measurement of a concept requires a prior theoretical conceptualisation. In this case, the concept of SES is sufficiently diverse, complex and difficult to operationalise and validate that specific definitions are often shunned: it is generally understood what the concept means and the variables used to operationalise it speak for themselves (Health Surveillance, 1998a).

Max Weber, in his attempts to define SES, thought that societal position was based on the three dimensions of power that he identified as class (largely economic), status (defined as one's life access to opportunity), and party power (the political dimension to Webber's theory). In our modern society, given the restraints of data, these are often operationalised in terms of some measure of income, education or occupation (Liberatos et al., 1988). In other words, variables such as income, education and occupation are simply surrogates for power, knowledge and influence.

Of the three generalised classes of SES variables stated above, occupation tends to be the most difficult on which to get reliable individual information. Even if correct occupational information can be obtained, categorising and ranking is often equally problematic. With income, inflation and different costs of living make it difficult to compare across time and space (Liberatos et al., 1988). The education variable has two advantages: it is the most straightforward, and it becomes relatively fixed early in life.

A review of studies published in the *American Journal of Epidemiology* between 1982 and 1985, on the relationship between SES and population health, found that the education variable was used in 45% of all cases, occupation in 22%, and income in 18%, while 15% used a variety of composite indicators to operationalise SES.

This begs the question of whether education was the best indicator or simply the easiest to operationalise (Liberatos et al., 1988). The same review reported that 40% of the studies conducted included an SES variable. However, in 42% of these cases it was treated as a potential confounder; in 26% it was a descriptive variable, and, most significant for our purposes, in 32% of cases SES status was considered a potential risk factor (Liberatos et al., 1988).

Clearly then, SES variables can be treated in a number of different ways depending on the goal of the study. However, given the current state of our knowledge, controlling SES unnecessarily should be avoided. Otherwise, there may be over matching, thereby reducing the explanatory power of the study's findings. In general, if one is unsure of the causal pathways it is best to run dual methodologies, where SES runs in both a controlled and an uncontrolled fashion, to determine whether SES is a contributing variable to the results. In epidemiological studies, this is often not the case: SES is simply controlled. Whilst this is a tacit admission by the authors that SES does make a difference to the phenomenon under study, by controlling it they are omitting the SES contribution (Liberatos et al., 1988).

It is often assumed that the issue of SES and differential health outcomes pertains to only a small percentage of the population, whose extreme deprivation is

manifested in significant health difficulties. Townsend defined deprivation as a state of observable disadvantage for an individual or among a group of individuals when compared to the society in which they live (Brenner, 1983). While deprivation does play a role in explaining why those at the lowest SES levels have poor health outcomes, overall it is not the major cause of the phenomenon being studied here. Many studies, including this one, use a diverse range of variables, to show a clear step-wise life expectancy (and other health outcomes) gradient from one SES group to the next at each level, not just a drop-off for those at the extreme lower end. For example, in The Whitehall Study, which will be discussed in more detail later, the second highest-ranking group of civil servants had significantly higher standardised mortality ratios than those of the highest-ranking group (Davey-Smith et al., 1990). Yet by most definitions these second tier British civil servants would be described as privileged. It is that phenomenon, rather than the connection between deprivation and poor health, that is most surprising in its robustness throughout the health inequality literature. It also quickly dispels the notion of some small feckless underclass imposing health costs on the rest of society; this is a problem that affects all social strata to varying degrees.

Some involved in this health inequality debate prefer the term "heterogeneities", as less value-laden than

"inequalities". They point to areas such as gender and genetic diversity, about which there is no normative presumption of equality, and no presumption that differences can be overcome by increasing fairness in society. However, for the purposes of this current work the term "inequalities" will be used, as for the most part we are focusing on socio-economic variables that can be affected by government policy and therefore can be (and some would argue should be) ameliorated (Hertzman and Evans, 1994).

Further, on the topic of terminology, one must be extremely cautious when using the term "determinant of health". In general, we will stick to the less equivocal yet somewhat more ambiguous term "correlate of health". Until a firm causal link can be established, it is difficult to elevate correlates to causation with any degree of certainty (Health Surveillance, 1998a).

CHAPTER 2

INTERNATIONAL AND HISTORICAL CONTEXT

Before proceeding with the findings of this Ontario study, it is important to understand the primary methods and findings of the debate that have preceded it. Studies concerning SES and differential mortality have been conducted for several decades in virtually all industrialized countries. The research tradition has

varied by not only the period, but also the place it occurred. For this reason the literature was reviewed not only chronologically but also by its location. Therefore, this section is divided to separate the U.S. and European research, with a third section on the Canadian contribution to this body of knowledge.

The United States

In 1973, Kitagawa and Hauser published *Differential Mortality in the United States: A Study of Socioeconomic Epidemiology*. The study was based on two data sets: individual level data from the 1960 Matched Record Study, and ecological or area-based data from the Chicago Area Study. The 1960 Matched Record Study linked death certificate information for some 340,000 individuals with census information pertaining to their education and household income. The authors found a strong inverse monotonic relationship between years of schooling and mortality (See table 1).

The data in Figure 1 are presented as standardized mortality ratios (SMRs), one of the most common ways that differentials in mortality among groups are presented. SMRs are the observed death rates in a unit compared to the death rate that would have been expected, if the age distribution were the same as a standard population.

Relationship between Education and Mortality				
	Mortality ratios			
	White male		White female	
Years of school completed	25-64 years	65+ years	25-64 years	65+ years
All persons	1.00	1.00	1.00	1.00
0-4 years	1.51	1.02	1.60	1.17
5-7 years	1.14	1.00	1.18	1.04
8 years	1.07	1.00	1.08	1.03
High school				
1-3 years	1.03	} .99	.91	} .94
4 years	.91		.87	
College				
1-3 years	.85	} .96	.82	} .70
4 years or more	.70		.78	
	Nonwhite men		Nonwhite women	
	25-64 years	65+ years	25-64 years	65+ years
All persons	1.00	1.00	1.00	1.00
0-4 years	1.14	1.04	1.26	1.05
5-8 years	.97	.93	1.06	.93
High school or college	.87	.97	.74	1.01

Source: The 1960 Matched Records Study, reported in Kitagawa and Hauser 1973, table 2.1, 2.2.

Table 1: Relationship between Education and Mortality

Therefore, from the table above we can see that white males with four or more years of college education has a 30% mortality advantage over the reference population (.70 SMR).

Overall, in quantitative terms, the least educated subgroup had a 65% greater danger of mortality than the most educated group in the study. The only subgroup to which this pattern did not apply was individuals over the

age of 65. The authors concluded that, with the exception of the elderly subgroup, the differences in mortality translates into approximately five years of life expectancy for young adults from the least to the most educated classifications. When Kitagawa and Hauser did the same analysis based on income, many of the same relationships were found (see table 2).

Relationship between Income and Mortality				
	Mortality ratios			
	White male family members		White female family members	
Family income	25-64 years	65+ years	25-64 years	65+ years
All persons	1.00	1.00	1.00	1.00
<\$2,000	1.51	1.10	1.20	.96
\$2,000-\$3,999	1.20	.99	1.12	.96
\$4,000-\$5,999	.99	}	1.00	}
\$6,000-\$7,999	.88		.92	
\$8,000-\$9,999	.93	}	.92	}
\$10,000 or more	.84		.96	
	White male unrelated individuals		White female unrelated individuals	
	25-64 years	65+ years	25-64 years	65+ years
All persons	1.00	1.00	1.00	1.00
<\$2,000	1.26	1.00	1.27	1.05
\$2,000-\$3,999	1.02	}	.73	}
\$4,000 or more	.77		1.01	

Source: The 1980 Matched Records Study, reported in Kitagawa and Hauser 1973, table 2.5

Source: The 1980 Matched Records Study, reported in Kitagawa and Hauser 1973, table 2.5

Table 2: Relationship between Income and Mortality

However, in this case there was a noticeable gender difference, with men experiencing a larger difference than women in the (SMRs) of the lowest income groups.

Kitagawa and Hauser realised that because they were using income and not wealth there was a possibility of reverse causation, whereby poor health was causing low income. Therefore, they concluded that education was the preferable variable for this type of study, because of its relatively fixed nature in early adulthood for most of the population.

Using the same data set, Kitagawa and Hauser created a multiple regression model to evaluate simultaneously the effects of education and income on mortality. They found that the two variables affected mortality largely independently of one another.

The second data set used by Kitagawa and Hauser, the Chicago Area Based Study, consisted of information collected at the census tract level for the census years 1930 through 1960. Using the median rental income as the variable for defining an area's socio-economic status, the authors allocated Chicago's census tracts into socio-economic quintiles. The tracts were then linked to their mortality data. For every period studied, the authors found a sharp inverse gradient between SES and mortality, with mortality approximately 60% higher in the low SES census tracts than in the highest. They found this difference in SMRs to be more or less stable over the

three decades studied, findings that directly contradict some of the other literature that will be reviewed later (Kitagawa and Hauser, 1973).

Following up on the work of Kitagawa and Hauser, Feldman et al. (1989) focused on educational attainment and mortality rates and how their relationship had changed over time. They used as their starting point the same data set used by Kitagawa and Hauser, the 1960 Matched Record Data Set. In addition, the authors obtained data sets for the years 1971 and 1984. The comparison indicated that for the white males in the study, mortality differentials had increased between the years 1960 and 1984. For example, in 1960, men aged 65 to 74 and in the least educated group (0-7 years) had only a 10% mortality disadvantage compared to those in the most educated group (13 years or more). However, by 1984 the results had changed dramatically, with the least educated group being at a 100% mortality disadvantage compared to the most educated individuals in the study (see figure 1).

The authors attributed this substantial change to a sharp decline in heart disease among the most educated members of the study, and in an attempt to explain the phenomenon more fully they employed a hazard regression model that included many individual risk factors such as smoking, obesity and high cholesterol levels. Even when these variables were controlled, education level still had

a significant impact on 1971 and later mortality rates (Feldman, 1989).

The studies by Wing et al. provide further evidence on the differences in life expectancy relating directly to heart disease across small areas. Working at the county level, and using the percentage of the labour force involved in white-collar occupations as the socio-economic variable to distinguish the counties, they observed changes in heart disease rates from 1968 to 1982. In 1968, the lower SES counties were at a slight disadvantage;

Figure 1: National Trends in Educational Differentials in Mortality

however, as in Feldman's study, this disadvantage increased substantially by the conclusion of the study in 1982 (Feinstein, 1993).

In Feinstein's paper he reports Wing and his colleagues attempted to explain why the socio-economic mortality differentials had increased.

They divided the state of Ohio into 500 economic areas, and categorised these areas according to whether they had experienced early or late onset in the decline of heart disease. Among the SES variables used were education (measured by the percentage of population that had graduated from high school) and income (whether average income was over \$10,000 in 1960), both of which were found to be significantly positively correlated with an early onset in the decline of heart disease. In this case, they believed that those from higher education and income groups were experiencing a much earlier decline in heart disease, resulting in a greater overall reduction in heart disease related deaths than experienced in lower SES areas. Wing argues that the small socio-economic gradient at the beginning of the study, and the early onset in the reduction in heart disease correlated with higher SES areas, explain why the mortality differential started to increase. In other words, higher SES individuals benefited earlier and more often from a reduction in a major cause of death, in this case heart disease, largely confirming the results of Feldman et al. (Feinstein, 1993).

Much of the above work reviewed focuses on SES variables such as income or education. An alternative view claims that mortality is higher in deprived areas where basic public services such as adequate housing or access to medical care may be unavailable. For example,

Haan et al. (1987) analyzed the results from the Alameda County Poverty Area Study, creating a multi-variant regression model where the dependent variable was area-based mortality rates. They controlled for a wide range of factors such as race, gender, age, smoking, obesity, and social support; and their independent variables included income, education, and a dummy variable constructed to represent those residents who lived in previously defined deprived areas. While the authors found that neither the income nor the education variables were significantly correlated to area mortality rates, there was a significant correlation between increased mortality and residing in a deprived area (see table 3).

Some socio-economic mortality differentials can be traced to specific causes of death. Other studies suggest that potential causes can be more closely traced to SES differentials of diagnosis and treatment outcomes.

Farley and Flannery (1989) used the Connecticut Tumor Registry for the period 1982 to 1985 to determine whether women of low SES status with breast cancer were less likely to receive an early diagnosis. They concluded that this was indeed the case. Such a finding is especially significant in the case of breast cancer, as this is one of the few diseases to display a reverse SES mortality differential incidence gradient, that is women of high SES suffer a higher incidence of breast cancer than low SES females.

AGE-, SEX-, AND RACE-SPECIFIC MORTALITY RATES PER 1,000, BY AREA OF RESIDENCE, OAKLAND, CA, 1965-1974								
AGE (YEARS)	WHITES			NONWHITES				
	POVERTY		NONPOVERTY	POVERTY		NONPOVERTY		
MALES								
35-44	12.5	(16)	3.9	(128)	6.4	(47)	4.4	(23)
45-54	32.1	(28)	9.3	(113)	10.2	(59)	14.3	(14)
55-64	29.6	(27)	23.0	(81)	15.6	(32)	0.0	(6)
>or=65	58.3	(48)	57.5	(111)	60.9	(23)	50.0	(2)
TOTAL NO. AT RISK	(119)		(433)		(161)		(45)	
AGE-ADJUSTED RATES PER 1,000	32.6		22.6		20.04		19.7	
FEMALES								
35-44	9.5	(21)	5.2	(154)	7.8	(64)	6.7	(30)
45-55	6.3	(32)	6.0	(149)	10.4	(67)	0.0	(11)
55-64	27.0	(37)	8.6	(152)	22.5	(40)	0.0	(5)
>or=65	38.3	(47)	39.1	(27)	33.3	(27)	50.0	(4)
TOTAL NO. AT RISK	(137)		(599)		(198)		(50)	
AGE-ADJUSTED RATES PER 1,000	19.7		14.53		17.99		13.9	

* NUMBERS IN PARENTHESES REPRESENT NUMBERS OF SUBJECTS

SOURCE: Haan et al. 1987

Table 3: Age, Sex and Race Specific Mortality Rates

Projections based on these findings determined that although women of low SES had a lower overall incidence of this disease, because of their late presentation their risk of death was actually greater than that of their high SES counterparts. Further, a greater percentage of the deaths of the low SES women were judged preventable. In fact, the rate of preventable breast cancer deaths in low SES women was 2.5 times higher than that of high SES women (see figure 3) (Farley and Flannery, 1989).

Studies such as this are significant because they demonstrate that it is not just lower SES populations that are more susceptible to disease, but that even in diseases

Figure 2: Projected Breast Cancer Death Rates

where high SES individuals are more susceptible, early diagnosis and more favourable treatment outcomes still benefit the higher SES groups. Because Farley's study took place in the United States, where access to health care is not universal, it would be easy to assume that this phenomenon would not occur in nations with more egalitarian health care systems. However, as discussed in the introduction, universal health care has had little impact on eradicating SES mortality differentials overall. In 1991, Cella et al. studied socio-economic status and cancer survival times for a wide range of cancers. Using education and income as their SES variables, they found that individuals with lower educational and income levels showed significantly shorter survival times than those in the highest group. These

survival times were associated with, but could not be fully explained by, the severity of the disease at initial presentation. Moreover, even after all known prognostic variables had been controlled, survival times were still significantly shorter among lower SES cancer patients (see figure 3).

Figure 3: Cancer Survival Probability by Education Level

Thus, unlike the breast cancer study where outcomes for low SES women were related to the late presentation of the disease, Cella et al. concluded that even when a wide variety of factors were controlled, including severity of disease at initial presentation, low SES cancer patients still had shorter survival times than others in the study (Cella et al., 1991).

In the 1980s, Rogot used The National Longitudinal Study to follow up the work by Kitagawa and Hauser. He found that life expectancy varied directly with the amount of schooling, family income and work force participation. The data were for more than 800,000 individuals in a prospective mortality study, thereby ruling out the

possibility of reverse causation (social selection) that was a potential alternative interpretation of Kitagawa and Hauser's cross-sectional methodology.

In terms of education, Rogot (1992) found approximately a six-year life expectancy differential between the highest and lowest educated group of males, and a five-year differential for females. For family income the differential between lowest and highest life expectancy was approximately ten years for males and 4.3 years for women. However the largest differentials were found when he divided the population between those who were in the labour force and those who were not: the differences then were 12 years for men and nine years for women. These differentials are by far the largest found in any of the studies reviewed and clearly show that participation in the labour force is an excellent SES indicator for determining differences in life expectancy. However, the possibility still exists that those who were out of the labour force at the start of his study were there in part for health related reasons that would ultimately manifest themselves in increased mortality (Rogot et al., 1992).

Using the same individual level data as Rogot, Anderson et al., (1997) studied the effects of community socio-economic status on mortality. In addition, however, in an 11-year follow-up mortality study, they assigned some 240,000 individuals to their census tract of

residence. Because they had data at both the individual and the census tract level, they were able to compare the results of family income (individual level data) versus median census tract income (ecological data) on mortality. Although they concluded that family income had a stronger correlation with mortality, they also found that the census tract information made a "unique and substantial contribution" to the understanding of differences in life expectancy (Anderson et al., 1997).

The final study to be considered from the U.S. literature is that by Diez-Roux et al. (1997). This study is important for two reasons: it is recent, and as the previous study it takes a multi-level approach to differences in life expectancy. Using 1990 census block measures, the authors concluded that living in a deprived neighborhood was associated with an increased incidence of coronary heart disease. Even after controlling for individual risk factors, the same general pattern was evident. In effect, the authors found that one's individual SES could not be completely protective if one lives in a lower SES area. Therefore, the authors concluded that neighbourhood environment is one of the causal pathways by which social structure affects coronary heart disease (Diez-Roux et al., 1997).

Europe

Since its publication in 1980, *The Black Report* has had a major impact on the understanding and direction of research on social inequalities in health. In many ways, it is to the British, and perhaps more generally the European, debate what the Kitagawa and Hauser study is to the United States. Its findings were controversial and sparked a lively and sometimes acrimonious debate, elements of which persist. The first contrast that is immediately obvious between this British study and much of the U.S. work is the use of occupation rather than education or incomes as SES variable. The British have an official and long standing tradition of measuring their SES by occupational classification. It appears for this reason that the vast majority of their early work in this area was occupationally based. In addition, although this has eased somewhat in more recent studies the British appear to do more occupationally based research than any other group. *The Black Report* used occupational classifications derived from death certificates as the socio-economic variable to form its numerators (in calculating mortality rates), and occupational data from the British census to form its denominators. Spouses who were not in the paid work force were assigned the same social class as their mates (Davey-Smith et al. 1990).

Black's findings (see table 4) were that individuals aged 15-64 who were in social class 5, the lowest social

class as measured by occupation, experienced mortality rates approximately twice as high as those in social class one. In addition to these socio-economic

THE BLACK REPORT MORTALITY OF MEN AGED 15 - 64 BY SOCIAL CLASS, 1971 - 5 AND 1976 - 81						
SOCIAL CLASS IN 1971	PERIOD OF DEATH					
	1971-5			1976-81		
	OBS	EXP	SMR	OBS	EXP	SMR
I	135	167.1	81	128	193.9	66
II	599	753.6	79	625	806.3	77
IIIN	378	414.0	91	450	429.3	105
IIIM	1258	1372.2	92	1435	1501.0	96
IV	694	720.8	96	774	710.6	109
V	369	317.3	118	358	289.1	124
ARMED FORCES	11	15.2	72	20	21.8	92
INADEQUATELY	90	51.6	174	86	45.1	191
DECRIBED	420	140.7	299	231	106.3	213
UNOCCUPIED						
TOTAL	3864	3863.6	100	4107	4107.4	100

SOURCE: Fox et al. 1985

Table 4: Mortality of Men aged 15 – 64 by Social Class

the end of World War II and the introduction of the National Health Service. One of the primary purposes of the National Health Service was to equalise access to health care in an attempt to generally reduce social inequalities in health. Black's findings suggested that although mortality rates as a whole had fallen sharply from 1930 to 1981, the widening inequality came about because of a particularly sharp decrease in mortality in those belonging to social class 1.

The methodology of *The Black Report* has been much criticised, primarily on the grounds of the quality of the data employed for its analysis. The use of two very different data sets is always problematic. In this case,

mortality differentials, Black was also able to determine that substantial regional variations existed within Britain itself.

As surprising as this might have been, even more surprising to many was that these inequalities had actually been increasing, according to Black, since

the death certificate data set for the numerator and the census data set for the denominator created what is often referred to in the literature as the "numerator-denominator problem". Reverse data checks have uncovered a tendency among some relatives filling out death certificates of loved ones, to promote the deceased to higher occupational positions than they ever held in life.

A second point of concern is that, because of the occupational SES measurement, *The Black Report* only considered individuals between the ages of 15 and 64. The number of deaths in this age group is relatively small given that death rates tend to be higher before the age of 15 and after the age of 64. Therefore, critics claim that this age group does not represent the totality of the British mortality experience. Further, in the light of Kitagawa and Hauser's findings that the elderly have very low SES mortality differentials, *The Black Report* has, by excluding this age category, inadvertently inflated the differences in life expectancy that exist in British society as a whole.

Another problem is that the size, or proportion, of the occupational classes changed substantially over time. This is particularly problematic for the fifth or lowest class over the four decades of Black's study. While the numbers and overall percentage of those belonging to class five dropped dramatically, the percentage of those involved in class 1 occupations rose. This suggests that

Black's mortality differentials for the more recent years of his analysis are relevant to an ever-smaller number of individuals. Even given these limitations however, and after many years of scrutiny, most agree that the fundamental conclusions were valid. *The Black Report* still serves as the pre-eminent contemporary UK document on socio-economic differences in life expectancy (Feinstein, 1993).

The numerator/denominator problem and retrospective nature of the Black Report were overcome in The Whitehall Study, in which British civil servants were followed longitudinally after being assigned to four different occupational classifications. The study revealed (see table 5) a mortality differential of almost 3:1 between the highest and lowest ranked groups of British civil servants. Even when some control variables such as smoking were introduced, the differentials were still significant (Marmot et al. 1987).

INEQUALITIES IN MORTALITY RATES IN THE UNITED KINGDOM IN 1971 AMONG PERSONS AGED 15 TO 64			
		MORTALITY RATES PER 1,000	
SOCIAL (OCCUPATIONAL) CLASS		MEN	WOMEN
I	PROFESSIONAL)	3.98	2.15
II	INTERMEDIATE)	5.54	2.85
III	SKILLED NONMANUAL)	5.80	2.78
III	SKILLED MANUAL)	6.08	3.41
IV	PARTLY SKILLED)	7.96	4.27
V	UNSKILLED)	9.88	5.31

SOURCE: Townsend, Davidson, and Whitehead 1988: Black Report, table 1.

Table 5: Inequalities in Mortality Rates in the United Kingdom

Moser et al. (1984) used the British OPCS Longitudinal Study to study the effects of unemployment on mortality. They followed a group of

men who, as of the 1971 census, were unemployed, some 4% of the total population. The standardised mortality ratio for this group was found to be 136. These men were, in general, of lower socio-economic status, but even controlling for socio-economic status their standardised mortality ratio was still 20 to 30% higher than the rest of the population. The authors concluded that stress associated with unemployment was a significant factor in the increased mortality. In addition, the spouses of these unemployed males had standardised mortality ratios of 126, well in excess of the reference population, and this too persisted after controlling for socio-economic status. Thus, the authors were able to conclude that unemployment is associated with adverse health not just for the unemployed individual but also for the family as a whole (Moser et al., 1984).

In 1997 Hart et al. measured mortality differentials based on SES at three different stages in an individual's life. The study used baseline measures taken in the early 1970s, when participants had been asked to identify their current occupation, their first position upon entry into the workforce, and their father's occupation. This information allowed the authors to classify the individuals into different SES classifications at three different stages of their lives. When a 21-year mortality follow-up was completed, those with higher socio-economic status were found to be at lower risk of mortality than

those in the study of lower SES. Further, the final screening - the one done in 1973 - was found to produce the greatest mortality differential. The authors concluded from this that it is low SES throughout one's life that contributes most significantly to differences in life expectancy, as opposed to the thesis that low socioeconomic status in childhood alone is enough to cause differences in life expectancy later in life. In general, because individuals born into low SES stay there throughout their lives, it is unclear from the study at which point, if any, this low SES starts to contribute to differences in life expectancy (Hart 1998). Much work has also been done in the rest of Europe. Of particular interest here is a Swiss study carried out in 1996, which used potential years of life lost (PYLL) as its health indicator. This indicator will be more fully defined later in this paper, where it will be used as the health indicator in a multiple regression model. The authors of the Swiss study thought it prudent to use PYLL instead of the commonly used SMRs, because it places more importance on deaths at a younger age. Using the by now familiar European occupational classifications they found that by using SMRs the social class mortality gradient was present at a rate of approximately 2:1. However, when switching to the PYLL statistic the gradient was even steeper, showing an up to 2.5 times disadvantage for the lowest occupational classification.

Because PYLL is closely associated with life expectancy, it is also used in the Swiss study to ascertain how the different causes of death contribute to overall mortality differentials. Not surprisingly, there is a considerable difference in causes of death between young and old in a population. For instance, accidents and suicides contribute disproportionately to the PYLL statistic because of the average young age of persons dying from these causes (see figure 4).

Mean YPLL (before age 75) per death, by social class and cause of death. Swiss death certificates 1979-1982. Males aged 15-74.

Source: Beer et al. 1993.

Figure 4: Mean YPLL (before age 75) per death, by social class and cause of death

Because these causes of death also tend to cluster in low SES groups, they have a compound effect when ascertaining their contribution to SES mortality differentials (Beer et al. 1993).

Finally, in 1990 the *Journal of Social Science & Medicine*, in conjunction with the World Health Organisation, produced a special edition looking at health and social inequalities in Europe on a country-by-country basis. However, while the exercise provided an excellent opportunity to look at the situations of individual nations, overall the articles were disappointing as they were largely descriptive and did not stretch the debate theoretically, beyond where it already stood. In many respects, it was a simple accounting of the different stages at which a number of European countries found themselves vis-à-vis socio-economic status and health.

Lahelma et al. (1990) studied socio-economic inequalities in Finland compared with other European countries. Breaking with European tradition, he used education as his socio-economic variable, and found that there were no major changes to the step-wise gradient in Finland throughout the 1970s. He concluded that Finland had a steeper SES mortality gradient than most European countries, and in particular the other Scandinavian countries (Lahelma et al., 1990).

Spruit (1990) used occupation classifications to study differences in life expectancy in the Netherlands. His goal was to determine whether socio-economic gradients could be predicted by pre-existing conditions such as overall health, smoking, height and a number of chronic conditions. However, even with all these conditions

controlled for, he concluded that socio-economic status still acted independently of other variables in producing differences in life expectancy (Spruit, 1990).

A study conducted in Sweden noted that country's overall egalitarian culture and the fact that it has been successful in reducing its overall level of SES differences in life expectancy to a level not achieved in most countries (Diderichsen, 1990).

A Belgian study by Laggasse et al. focused on the concept of avoidable mortality and how it affects differences in SES mortality differentials. The concept of avoidable mortality states that in the absence of health services mortality would be solely determined by social, environmental and genetic factors. However, with the introduction of health care some diseases are either curable, or entirely preventable. Therefore, the concept of avoidable mortality, as developed by Rutstein, focuses on a selected set of diseases whose occurrence could be dramatically reduced or eliminated by preventative or curative intervention. The findings in this study showed that the major portion of SES differences in mortality came about because of those causes of death that were deemed to be avoidable or preventable but were neither avoided nor prevented in great numbers by those Belgians of lower SES. Moreover, the most discriminatory causes of death are most heavily represented in socially deprived areas (Laggasse et al. 1990).

An examination of the European literature reveals that in many respects it parallels the U.S. literature, but it differentiates itself with its heavy reliance on occupational as opposed to educational or income variables. While both the United States and Europe use some cross-sectional and ecological level data, both have access to a significant number of longitudinal and individual level data sets, allowing them to overcome many of the deficiencies of ecological and cross-sectional data. In Canada, for the most part, this is not the case.

Canada

Canadian authors have tried to cover many of the same issues as their U.S. and European counterparts. However, researchers in Canada are severely limited by the quantity and type of data to which they have ready access. There are no substantial longitudinal individual level mortality studies and information garnered from death certificates is often inadequate, inaccurate, and poorly coded for this type of research. As a result, much of this type of analysis in Canada is done at the census division or county level, both of which are too large to be called homogeneous (an important ecological methodological assumption) in any meaningful way. Nevertheless, data shortcomings notwithstanding, many Canadian authors have tried to ascertain the situation concerning socio-economic status and differences in health outcomes in Canada.

One early attempt was a paper by Wilkins and Adams (1993), entitled "Health Expectancy in Canada in the late 1970s", in which information on mortality was combined with information garnered from the Canada Health Survey on short- and long-term activity limitations of the Canadian population. By combining this mortality and morbidity information, Wilkins developed a new statistic: health expectancy. He felt this type of analysis was useful because health implies not only longevity but also a certain quality of life. While overall life expectancy is increasing, so are rates of disability, especially in the elderly (Millar, 1983). By combining these two data sets, Wilkins concluded that much of what was already known about life expectancy in Canada also pertains to health expectancy (i.e., those who live in the west tend to live longer and healthier lives than those living in eastern Canada). Further, those who live in large urban areas live longer and healthier lives than do their rural counterparts. Finally, and most important from a socio-economic perspective, those belonging to the highest income group of families lived 4.5 years longer compared to their low income counterparts (see table 6)

Relevant to our discussion of health expectancy as opposed to life expectancy is that life expectancy of the poor was further disadvantaged when one took into account chronic conditions that reduced the overall quality of

life for the lowest economic group (Wilkins and Adams, 1983).

The primary goal of Hay's 1998 paper "Socioeconomic Status and Health Status: A Study of Males in the Canadian Health Survey" was to investigate the relationship between SES and individual *morbidity*. A secondary goal was to determine which aspects of SES - income, occupation, or education - showed the greatest morbidity differentials. In general, he found the three indicators showed differential morbidity and, when combined in a regression model, showed some independence along with some overlap. Of the three, income was consistently the best correlate with morbidity, while the results from occupation were the most inconsistent. Because Hay found income, not education, to be the best correlate he feared that low-income Canadians might have drifted to that status because of poor health, thereby invalidating the normal direction of causality of the predictive model. However, while not as strong as income, education was also a consistently good indicator of differential morbidity. Hay concluded that most of the differential morbidity was social causation while only a smaller secondary percentage was social selection (reverse causation) and he recommends we keep in mind that both processes may be at work in any findings of this type. Hay's study confirms Wilkins' findings, and those of many other authors in other jurisdictions, that it is not only mortality, but also

morbidity that disproportionately affects those of low SES status (Hay, 1988).

DISTRIBUTION OF HEALTH EXPECTANCY OF EACH SEX, BY AGE, REGION, COMMUNITY SIZE, AND INCOME LEVEL, CANADA, LATE 1970'S (IN YEARS)									
	LIFE EXPECTANCY			DISABILITY-FREE LIFE			QUALITY-ADJUSTED LIFE		
	M	F	T	M	F	T	M	F	T
AGE									
AT BIRTH	70.8	78.3	74.6	59.2	62.8	61.0	65.8	71.7	68.7
15 YEARS	57.2	64.5	60.9	46.2	49.4	47.8	52.4	58.1	55.2
25 YEARS	48.1	54.8	51.5	37.6	40.4	39.0	43.5	48.7	46.1
45 YEARS	29.6	35.7	32.7	20.6	23.6	22.1	25.6	30.5	28.1
65 YEARS	14.4	18.7	16.7	8.2	9.9	9.1	11.5	14.7	13.3
75 YEARS	8.9	11.7	10.6	4.6	4.6	5.0	6.9	8.6	7.9
REGION									
ATLANTIC	70.5	78.3	74.4	56.7	61.8	59.5	64.4	71.2	67.8
QUEBEC	69.7	77.6	73.6	60.4	63.1	61.8	65.5	71.5	68.5
ONTARIO	71.2	78.4	74.8	59.5	63.7	61.6	66.1	72.1	69.1
PRAIRIES	71.5	78.9	75.2	59.4	63.0	61.2	66.3	72.1	69.2
BRITISH COLUMBIA	71.5	78.9	75.2	57.4	59.8	58.6	65.5	70.9	68.2
COMMUNITY SIZE									
LESS THAN 1,000	69.1	76.0	72.5	56.6	63.6	60.1	63.8	71.0	67.4
AND RURAL	69.9	78.1	74.0	56.7	62.2	59.4	64.3	71.6	68.0
1,000-9,999	69.8	77.8	73.8	58.4	64.1	61.2	64.9	72.2	68.6
10,000-99,999	70.1	77.7	73.9	59.1	62.1	60.6	65.5	71.3	68.4
100,000-999,999	71.8	78.8	75.3	62.8	65.1	64.0	67.9	73.3	70.6
ALL SIZE GROUPS	70.2	77.5	73.8	59.3	63.2	61.3	65.6	71.7	68.6
INCOME LEVEL									
LOWEST	67.1	76.6	71.9	50.0	59.9	54.9	59.4	69.7	64.6
SECOND	70.1	77.6	73.8	57.9	61.8	59.9	64.8	71.7	68.0
THIRD	70.9	78.5	74.7	61.1	64.3	62.7	66.8	72.7	69.8
FOURTH	72.0	79.0	75.5	62.6	63.5	63.1	68.1	72.8	70.5
HIGHEST	73.4	79.4	76.4	64.3	67.5	65.9	69.7	74.8	72.3

SOURCE: Wilkins et al. 1983

Table 6: Distribution of Health Expectancy of Each Sex, by Age, Region, Community Size, and Income Level

Liaw et al.'s (1989) paper "Intraurban Mortality Variation and Income Disparity: A Case Study of the Hamilton-Wentworth Region", closely parallels this current study because it studies both SES and mortality at the

census tract level. Liaw's data sources are also similar, in that deaths were taken from the death certificate database and coded by census tract, whereas socio-economic data were taken from the census. The one major difference was that instead of converting these data into life expectancies, as will be done in this study, Liaw et al. converted them to an age specific death rate based on the 1981 census. The socio-economic indicators used were income (defined as a median family income for each census tract), unemployment rate, percentage of blue-collar workers, single individuals and married individuals. By applying these to a model, they found that all the variables, with the exception of percentage of blue-collar workers, were correlated with mortality in the expected direction. Those tracts with high median income and/or a high percentage of married individuals had a lower age standardised mortality ratio compared to those tracts that had high rates of unemployment and/or a high percentage of single individuals. Overall, they concluded, like other authors they cited, that Canada had shown a decrease in SES mortality differentials since the 1920s. Further, although income explains about 50% of mortality differential, additional variables did not significantly improve its explanatory power. From this they concluded that important behavioural and environmental data not captured in census data contribute significantly to the portion of SES differences in life expectancy not captured

by income. The authors also found the common pattern whereby female differences in life expectancy are more fragmented and less susceptible to income disparity. They attributed this in large part to "the biological superiority of females" (Liaw et al., 1989).

Jerrett et al.'s 1990 study, "Socioeconomic and Environmental Covariates of Premature Mortality in Ontario", looked at socio-economic mortality differentials and at a number of other variables not normally associated directly with socio-economic status in Canada (e.g., access to health care and the level of environmental pollutants). The study was carried out at the census division (county) level in Ontario. The traditional SES variables include the percentage of those in a county below the low-income cut-off line; education, based on completion of high school, and an occupational variable based on the percentage of the population involved in manufacturing. Manufacturing was seen as a protectant because jobs in that industry tend to be relatively stable and well paying. A second occupational classification was created for primary industry occupations that were viewed as relatively unstable and having dangerous working conditions. In addition to these regular socio-economic variables, Jerrett et al. introduced variables concerning what they termed the biophysical environment. These data are available at the census division or county level in Ontario and measures the environmental quality in each of

the divisions. Other control variables included items pertaining to the number of physicians per capita, percentage of aboriginals, and baseline smoking rates.

With regard to the females in the study, Jerrett found strong correlations between low income and education level and differences in life expectancy. Weaker correlations were found for occupational classification, smoking and aboriginal population. There was no significant correlative effect with the number of physicians per capita in the census division. For males, the high correlative values were in education, primary industry and percentage of aboriginals. While Jerrett admits that this type of research is exploratory in nature, and acknowledges the limitations of working ecologically in large census divisions, in general he does see it as a first step to improving upon the baseline SES data to which many other studies confine themselves (Jerrett et al., 1998).

The Alberta Health Surveillance Unit study "Life Expectancy in Alberta: A Socioeconomic Perspective" is similar to this current study in that it is at the provincial level and is ecological in nature, although their unit of study is conducted at the considerably larger public health unit (PHU) of which there are 17 in Alberta, as opposed to the 1540 census tracts under study in this paper. The studies also have in common the use of life expectancy as a health indicator, and the exploration

of a wide range of socio-economic variables derived from the 1991 census.

The Alberta study, computed a life expectancy for each of the 17 PHU's in Alberta. A clear gradient of lower life expectancies was found in the northern part of the province. Life expectancies ranged from 79 years in the Calgary area to as low as 73 years in some of the northern public health units. Ecological SES variables were combined to increase explanatory power. They used in their model 10 socio-economic variables, many of which are tested later in this paper. They included:

- Percentage of population of aboriginal origin
- Percentage of population Catholic
- Percentage of population landed immigrants
- Median income
- Average number of years of schooling
- Percentage of population in the labour force
- Percentage of births out of wedlock
- Number of live births to teenage mothers
- Average number of children still living at home
- Percentage of families headed by a single parent.

The authors found a strong correlation between all these indicators and life expectancy at birth, and most were highly inter-correlated with each other (see table 7).

In an attempt to quantify the relative importance of the variables, the authors grouped them into two indices: an index of social/cultural discord that included such

variables as lone parent families and percentage of births to teenage mothers; and an index of economic status. They then ran a regression analysis, which determined the results below (see figure 5).

CORRELATION BETWEEN SELECTED SOCIOECONOMIC VARIABLES AND LIFE EXPECTANCY AT BIRTH (ALBERTA, 1991)										
	ABR	CATH	IMM	INC	EDUC	UNEMP	WED	TEENF	CHLD	
LIFE EXPECTANCY AT BIRTH	-0.9	-0.60	0.52	0.25	0.68	-0.81	-0.92	-0.94	-0.72	-0.49
ABR		0.60	-0.44	-0.18	-0.70	0.88	0.90	0.96	0.88	0.46
CATH			-0.20	0.19	-0.35	0.62	0.69	0.53	0.53	0.44
IMM				0.29	0.76	-0.07	-0.38	-0.44	-0.49	0.42
INC					0.55	-0.02	-0.04	-0.28	-0.12	0.01
EDUC						-0.43	-0.51	-0.69	-0.80	0.07
UNEMP							0.86	0.88	0.74	0.77
WED								0.94	0.71	0.59
TEENF									0.81	0.53
CHLD										0.20

Source: Health Surveillance, (1998a).

Table 7: Correlation between Selected Socioeconomic Variables and Life Expectancy at Birth

The index of social/cultural discord had a slightly larger negative effect than the positive effect brought about by favourable economic circumstances. While the authors claim that 87% of differential life expectancy at birth can be accounted for by these two indices appears extremely high, (probably due to a small n of 17) they seem to have captured the essence of the social and economic elements contributing towards differential life expectancy in Alberta (Health Surveillance, 1998a).

Figure 5: Relative Impact of the ISD and MES Factors

The final project reviewed here is the most similar to the current study. In a series of related studies, Wilkins et al. used data starting in 1971 and running all the way through 1991, with 1996 data soon to be released. The basic methodology employed is a study of mortality by census tract in urban Canada at the census tract level. In fact, the data used for Wilkins' study and for this current study are exactly the same in that the deaths are from the Canadian Death Database, recoded from the county to the census tract level. Population numbers (needed to calculate life expectancies) are taken from Wilkins' non-institutional census tract populations. Wilkins only uses one measure of SES: the percentage of a census tract's population that is below the low-income cut-off line. From this single variable, he divides Canadian census tracts into quintiles.

One major difference between Wilkins and the current study is that Wilkins constructed his quintiles within each Census Metropolitan Area (CMA) before aggregating to the Canadian level. He believed that the inter-metropolitan differences in income, housing and other living costs required some sort of control in order to avoid significant regional variations that would have dominated his analysis as opposed to the SES he was investigating. For example, 36% of the population of metropolitan Toronto would have been placed in Q1, the most privileged quintile, while four metropolitan areas in

eastern Canada, Chicoutimi, Sherbrooke, Trois Riviere and St. John, would have had no census tracts in that quintile whatsoever without this intra-city sorting. In this thesis I have tested the analysis both ways but because the variations in living standards and cost of living are not nearly as great across Ontario as they are across Canada as a whole, the construction of quintiles within each CMA before aggregation was not deemed necessary. Wilkins defends his use of LICO (low-income cut-off line) on the grounds that it is the pre-eminent SES measure, taking into account community and household size before being used by the researcher.

While Wilkins' results show that the poor in Q5 are at the greatest disadvantage, there is the familiar monotonic gradient between all quintiles. The results also show that the data from 1971 through 1991 reveal that mortality differentials based on LICO tended to persist. Therefore, for example, in 1971 shortly after the advent of universal health care, the differential between Q1 and Q5 was about six years for males and three years for females. By 1986, the discrepancy was approximately 5.5 years for males and two years for females. In short, Wilkins notes a small decrease in differences in life expectancy between 1971 and 1986, and virtually no decrease between 1986 and his 1991 findings (see figure 6).

LIFE EXPECTANCY AT BIRTH (IN YEARS) BY SEX, BY INCOME QUINTILE, URBAN CANADA, 1971 AND 1986

LIFE EXPECTANCY AT BIRTH (IN YEARS) BY INCOME QUINTILE, BY SEX, URBAN CANADA, 1971 AND 1986

INCOME QUINTILE	TOTAL			MALE			FEMALE		
	1971	1986	86-71	1971	1986	86-71	1971	1986	86-71
TOTAL	74.5	77.1	2.6	70.6	73.8	3.2	78.4	80.4	2.0
QUINTILE 1	76.6	78.5	1.9	73.4	76.1	2.7	79.7	80.9	1.2
QUINTILE 2	75.9	78.1	2.1	72.4	75.3	2.9	79.4	80.8	1.4
QUINTILE 3	74.6	77.5	3.0	71.0	74.4	3.4	78.1	80.7	2.6
QUINTILE 4	74.4	76.9	2.5	70.6	73.5	2.8	78.1	80.4	2.2
QUINTILE 5	72.0	74.8	2.8	67.1	70.4	3.4	76.9	79.1	2.2
DIFFERENCE Q1-Q5	4.6	3.7	-0.9	6.3	5.6	-0.7	2.8	1.8	-1.0
RATIO Q5/Q1 (X 100)	94.0	95.3	+1.3	91.4	92.6	+1.2	96.4	97.7	1.3

Source: Wilkins et al. (1991)

Figure 6: Life Expectancy at Birth by Income Quintile, by Sex, Urban Canada

Further, Wilkins points out that life expectancy differentials as measured by low-income cut-off were twice as large as those found between Canada's five regions. He concluded that mortality differentials based on SES for

the 1980s were about as large as regional disparities were in the 1950s. In general, Wilkins sees some improvement in SES differences in life expectancy in Canada, but the goal of health for all by the year 2000 will clearly not be attained (Wilkins et al. 1991).

Summary

U.S. and European studies comprise both mortality and morbidity studies, and include longitudinal, cross-sectional, individual and ecological research. The major difference is that European studies, especially British, rely much more heavily on occupational measures, while those in the United States lean more toward education and income measures of SES. To some degree, it appears the British pioneering of much of the work in this area, combined with their heavy reliance on an occupationally based method of determining SES, influenced many others from outside Britain who started their research in SES mortality differentials using occupation as their SES variable. However, over time, others, and to a lesser extent British researchers, concluded that occupation may not be the best SES indicator and the diffusion of its use from the early British research has waned as others employ a multitude of economic and educational indicators that supplement or supplant occupation as their measure of SES. Canadian studies tend to be limited by availability of data, and therefore most individual level

studies are on morbidity rather than mortality, due to the lack of access to longitudinal mortality data. As a result, most mortality studies in Canada are cross-sectional and ecological. Compounding this limitation is the fact that the geographic territories used in Canada are often very large (e.g. the 17 public health units in Alberta or the 49 census divisions in Ontario). It appears that because basic data are so much less available in a Canadian context, many authors jump directly to elaborate statistical techniques and model building. Whereas studies such as "Whitehall" are noteworthy for their simplicity and direct application of sound individual longitudinal data, it is only with a considerable effort that those in Statistics Canada have eventually been able to convert their data for use at the census tract level. Even ecological studies done at the more homogeneous census tract level are still considerably more problematic than those done at the individual level are, and it is this problem that we shall address in the next section.

CHAPTER 3 DATA AND METHODS

The purpose of this study is to examine differences in 1991 life expectancy for the population of Ontario, when that population is segmented by a wide range of SES variables. This study is an ecological study, conducted at the census tract level; as such only the 10 CMAs, are included. They are: Ottawa, Oshawa, Toronto, Kitchener, London, Windsor, Sudbury, Thunder Bay, Hamilton and St. Catharines.

Death data in Canada are archived in Statistics Canada's Canadian Mortality Database. Geographic coding for the Ontario database is done at the level of county or census division, of which there are 49. Statistics Canada, using street directories and postal code conversions, was able to take the deaths coded at the county level and recode them at the much smaller census tract level. This is an important upgrade in the quality of the data because ecological studies of this type are only truly valuable if the units are relatively small and homogeneous. While working at the census tract level is still in some ways problematic, it is infinitely preferable to working at the census division level, which bears neither of these two characteristics. Many researchers do not have the choice, since they do not have access to data at the census tract level. Thus it is hoped that the conversion of the death data from the 49 census divisions into approximately 1540

census tracts makes the findings of this study considerably more robust and informative than many of those done at the census division level.

The Statistics Canada conversion made available a database of all the deaths in 1991 in all 10 Ontario CMAs. Age at the time of death is coded in five-year cohorts, by gender of the deceased, and is placed in the last census tract of residence of each individual.

The second set of data required to calculate life expectancies is population counts. The most important consideration in the population counts for this purpose is that some census tracts contain large institutional populations. Clearly, institutions such as hospitals, hospices or retirement homes, where large numbers of people reside only at or near their time of death, reflect neither the SES composition of the neighbourhood in which that institution is situated, nor the SES of the individuals who died there. To get around this problem Statistics Canada carried out a special compilation of population data which relied not on the raw census tract population counts, but rather on the adjusted non-institutional population of all the census tracts included in this study.

With the death and population data in place, we now turn to the independent variables, the socio-economic data that will be used to investigate differences in life expectancy. All the socio-economic data in this study were acquired from the 1991 census. Most of these data were

collected by Statistics Canada through their *Profile Series*, a publication largely based on the long form of the census given to a 20% sample of the Canadian population. A literature review was then conducted to investigate what types of variables had been used by other researchers, and these were compared with the information available from the 1991 census. It was determined that 24 individual variables could be closely replicated from Statistics Canada data, and an analysis attempted for this current study. The 24 variables were placed into five main categories: economic, education, occupation, housing and social.

The basic procedure for determining how a variable performed in identifying differences in life expectancy was as follows. Once a variable was selected, for example median income, all the tracts in Ontario were then ranked from the highest median income tract to that with the lowest median income. The census tracts were then classified into quintiles. Quintile 1 contained the highest median income group, while quintile five contained those tracts with the lowest median income. The convention used throughout the study was that quintile 1 was assigned to the groups who were hypothesised to have the highest SES. In theory, this quintile should also have the longest life expectancy although, as will be demonstrated, choosing the projected direction of some SES variables is not as straightforward as in the case of median income.

Once the neighbourhoods had been placed in their respective quintiles, the corresponding death and population data were used to generate life tables for each quintile. Because sex has such an overwhelming role in overall life expectancy, three tables were created for each quintile: one for the entire population, one for males, and a third for females. Therefore, for each variable a total of 15 life tables were created, three for each quintile (see appendix A for an example). If the SES variable performed as hypothesised, those in quintile 1 would have a longer life expectancy at birth than those in quintile 5. Further, as discussed earlier, because this is not simply a case of deprivation as represented by quintile 5, a step-wise monotonic gradient should be evident between all quintiles. It is the overall difference and the gradients that will be looked for in analysing the results of the individual SES variables.

Studying population health is a complex and dynamic process. Life expectancy is often used to represent the health status of a population, with the underlying assumption that the cycle of births and deaths is modified by biological, economic, social, and environmental processes. These factors in turn affect population health and ultimately a population's life expectancy (Health Surveillance, 1998b). In many studies of this type, standardised mortality ratios (SMRs) are used instead of life expectancy to illustrate differences in mortality

among different SES groups. While both life expectancy and SMRs have their strengths and weaknesses, it was felt overall that life expectancy had several strengths that warranted its use here. First, life expectancy calculations do not require the creation of an arbitrary reference population. That is to say, populations with different age structures can be compared without any adjustment. This makes more straightforward the comparison of results at different times in different places, as the life expectancy results are self-adjusting for any given population structure. Second, it was felt that the general public has a better intuitive feel of what life expectancy actually consists of, which makes the findings, at least on the surface, easier to interpret (Manuel et al., 1998). However, the last assertion is only partially true. Many lay people believe they know what a life expectancy calculation consists of, but there are several assumptions of which they are probably not aware. Life expectancy is defined as "the average number of years an individual of a given age is expected to live if current mortality rates continue to apply" (Health Surveillance, 1998b). The key to that definition is perhaps the most misunderstood component of life expectancy, that is "if current mortality rates continue to apply". Thus, an infant's life expectancy is based on the assumption that when s/he reaches age 60, the current mortality rate for sixty year olds will apply to him/her; if those rates do not apply 60

years hence, the life expectancy generated at the time of that infant's birth will be incorrect.

In recent decades, only small changes in life expectancy have been experienced in the industrial world, leading some to believe that life expectancy is not a very sensitive indicator. However, if a society changes rapidly, this will manifest itself in life expectancy relatively quickly. The most recent example of this is the decade or so of changes in Russia that has led to a dramatic decrease in life expectancy for its population (Health Surveillance, 1998a).

Life expectancies then are statistical abstractions created from life tables. One method that could be used to create a life table is to follow a group of individuals born in and around the same time through to their death and calculate an average life expectancy for that group. However this method is more often used in medical studies where the individuals under study have a relatively short life expectancy from their entry into the study and are generally termed "Survival Analysis" (Health Surveillance, 1998b). The more common type of life table, and the one being used here, is the current or period life table. It is cross-sectional and based on a hypothetical population of 100,000, using the specific age, sex and mortality rate of the population under study (Ng and Gentleman, 1995). This is an actuarial approach to life expectancy; all that is needed to conduct the study are the deaths and

population, and the age structures of both. Not surprisingly, because we are dealing with a statistical or mathematical abstraction, there are a number of different techniques for constructing these life tables. However, no matter what method is used, there is the important underlying assumption that in life expectancy there is no specific cohort death rate. That is, the death rate at any given age is not a function of any unique event that would not pertain to individuals born later. Although there might be numerous conditions where this assumption would not hold true, nevertheless, if populations are sufficiently large then short of any one catastrophic event, this would not have a significant effect on overall life expectancy (Health Surveillance, 1998b).

The main difference between methods of calculating life expectancy is the way they transform age specific death rates to the conditional probability of death. This is because there are assumptions necessary to describe the deaths within an age interval, which influence the probability of death. Chiang, the most widely used life expectancy table method, assumes that this probability is the same as the reference population (Manuel et al., 1998).

In a recent study of life expectancies among public health units in Ontario, several different methods were used including Chiang's (see figure 7). Although differences were observed, the Chiang method showed the smallest differentials between public health units, making

it the conservative choice for one wishing to seek out SES mortality differentials. After a similar study, The World Health Organisation concluded that although different

Source: Ng et al., 1995.

Figure 7: Different method for calculating Life Expectancy & their results

In addition to the life expectancy calculation method, there are two other considerations that could influence life expectancies of given populations. First, because we are using abridged life tables that in general use five-year cohorts, the point at which the final age cohort ends

methods are based on slightly different assumptions they do not yield significantly different results when used in developed world populations (Ng and Gentleman, 1995).

The Chiang method will be used here because: a) it is the most widely used; and b) based on the Ontario study it gives the most conservative differentials.

is extremely important. At one time the last cohort for individuals was usually 85 and above, but with an increasing number of individuals living past the age of 85, this cohort became increasingly problematic in determining accurate life expectancies. Many death databases now extend their cohorts to 90 or 95 and beyond. Because the actual death rates are known for these (extended) cohorts the results tend to be more accurate than those found in the data sets that truncate the last cohort at age 85. This truncation and the way these deaths are handled give the three different Chiang results in the above figure 7. This study follows closely the Chiang method in the centre of figure, which assumes that deaths over the age of 95 occur at the age specific death rate of the general population, which can be obtained from the unabridged life tables published by Statistics Canada. Fortunately, the Statistics Canada database provided for this study goes all the way up to age 94, leaving only a relatively small number of deaths to be estimated for those individuals aged 95 or over (Manuel et al., 1998).

A final consideration when calculating life expectancy is that certain segments of a population tend to be undercounted in any census. In fact, some researchers have concluded that this consistent undercounting has a much larger influence on the life expectancy than the methodology used. In a recent study of all of Canada it was concluded that Ontario had the largest under coverage

of any province, with a rate of 3.6%, which could potentially affect the life expectancy calculation by up to approximately 84 days (Ng and Gentleman, 1995). Using a reverse record check Statistics Canada was able to determine that these undercounts tend to apply disproportionately to low-income Canadians. When one applies a corrective factor to the population denominator, it has the overall effect of reducing differences in life expectancy based on the SES variable low-income cut-off line by as much as half a year (Wilkins et al., 1991). In general, however, it was not possible for us to adjust our census count for all the variables included in the study. Statistics Canada's undercount analysis pertains only to a very limited number of variables, usually centring on low income. Therefore, it was decided that if all variables could not be adjusted, then none should be adjusted, keeping in mind that, in general, Canadians who have a lower socio-economic status tend to be undercounted and therefore any differential mortalities found may be slightly overstated. Using the above methods some 24 socio-economic variables were tested for their effects on differential life expectancies. The findings can be found in the next section of this paper.

Before turning to the individual findings, we would like now to delve into the second goal of this paper, to combine a number of these individual SES variables into a multiple regression model. While often these types of

models are created in order to estimate how much SES variables can explain about differences in life expectancies, that is not the case here. The more modest goal of this model is simply to generate the most accurate socio-economic profile of the 10 communities under study. From here we will use the predictive model and ask "Which of the 10 cities' life expectancies cannot be predicted by the model?" In other words, which have higher life expectancies than would have been predicted by their SES profile and which, if any, have lower? This will be done by introducing into the model dummy variables representing the cities, alongside the SES variables already chosen for their predictive capability. In so doing, we are trying to answer the question, "Can a city's life expectancy be predicted by its socio-economic profile?" as defined by the variables included in the model.

For reasons of continuity, it would be preferable to calculate a life expectancy for each of the 10 communities under study. Up to this point in the study, health outcomes have been measured by life expectancy for all the individual variables tested. However, in order to generate meaningful results we require relatively large populations, and it is therefore impossible to generate these life expectancies at the census tract level. The most that could be done would be to generate a life expectancy for the 10 different cities involved, and with only 10 life expectancies or 10 cases, it would not be possible to do

meaningful regression work of the type stated above. For this type of analysis we would have to implement a different mortality indicator that could be calculated meaningfully at the census tract level and then "grossed-up" for a citywide score.

Fortunately, there is another mortality indicator highly correlated with life expectancy that can be calculated in this fashion. It is known under a variety of names but we will refer to it here as potential years of life lost (PYLL). It correlates well with life expectancy because it places a heavy emphasis on deaths and the ages at which they occur, with deaths of younger individuals weighing much more heavily on reducing overall life expectancies of a population. Another advantage of using PYLL is that the data necessary to calculate it are the same as those used to calculate life expectancies: that is, deaths and the ages at which they occur and the population and age structure of the same areal units. For PYLL an assumption is made that individuals are expected to live to a certain number of years, usually 75. To calculate the numerator for PYLL one simply has to find a death in a neighbourhood, determine at what age it occurred and subtract that number from 75. For example, if an individual has died at age 20, and if 75 is the assumed age of death, there are 55 potential years of life lost (PYLL) for that individual. The deaths in a given census tract

are then summed and that total gives the numerator for the PYLL.

With the exception of the choice of assumed age of death, the calculation of the numerator for PYLL is relatively straightforward. However, the issue of how the denominator is to be calculated has been the subject of considerable debate.

In its simplest form, many researchers have used the population of the corresponding area. In our case, we could use the somewhat more sophisticated non-institutional population. However, using this cursory denominator misses two points: different census tracts will have different age structures; and residents of a census tract over the age of 75 cannot add to the numerator but are included in the denominator. Thus, any census tract heavily weighted to citizens over that age would be heavily affected. It makes sense, therefore, if one has the age structure of a population, to remove individuals over the age of 75 so that only those individuals who could potentially have added to years lost are included in the denominator. However, even once those over the age of 75 are removed from the denominator the underlying age structure of the rest of the population has still not been adequately taken into account, and its effect on the outcome could still be significant. Given that in most of these types of studies the basic age structure of the population is known, it is prudent to increase accuracy by

making the denominator sensitive to this age structure. In other words, the denominator can be calculated in much the same way as the numerator. For example, one would take every 20-year-old residing in the census tract and conclude that they each had 55 years of life left to contribute to the denominator. Summing this for all individuals under the age of 75 would give one an age-sensitive denominator. Researchers who have tested these three different approaches to determining the denominator have found small but significant differences to the overall results of their studies (see table 8). Accordingly, it will be the third, or age-sensitive denominator, that will be used in this current study (Marlow, 1995).

By using this method we are able to create a health indicator by neighbourhood that is best described as years of life lost over potential years of life, or YLL/PYL. This number is most easily comprehended when it is expressed as a rate per 100,000 of potential years of life. Given that this calculation can be done for all 1540 census tracts, we are then able to proceed with our regression model, as described above, preserving all 1540 data points while maintaining a high degree of comparability and correlation with the life expectancy of these 10 CMAs.

POTENTIAL YEARS OF LIFE LOSS DEATHS FROM ALL CAUSES WALES 1987-91								
	YLL/10,000 TOTAL POP		YLL/10,000 POP<75Y		YLL/PYL (PER 1000,000)		SYLL RATIO	
	RATE	RANK	RATE	RANK	RATE	RANK	RATE	RANK
MALES DHA:								
MID GLAMORGAN	939	1	980	2	239	2	106	1
PEMBROKESHIRE	937	2	983	1	245	1	104	2
GWENT	913	3	957	3	236	4	102	3
WEST GLAMORGAN	903	4	950	4	237	3	100	4
GWYNEDD	882	5	937	5	232	6	100	5
EAST DYFED	866	6	918	6	234	5	95	7
CLWYD	862	7	911	7	225	8	98	6
POWYS	850	8	902	8	230	7	94	9
SOUTH GLAMORAN	820	9	859	9	206	9	95	8
WALES	888		834		230		100	
FEMALES DHA:								
MID GLAMORGAN	571	1	621	1	156	2	110	1
PEMBROKESHIRE	552	2	609	2	158	1	105	2
GWENT	519	3	565	4	143	5	99	3
WEST GLAMORGAN	508	4	564	3	149	3	96	6
GWYNEDD	504	5	390	6	141	6	97	5
EAST DYFED	494	6	341	8	135	8	98	4
CLWYD	492	7	346	7	140	7	96	7
POWYS	490	8	583	5	145	4	94	8
SOUTH GLAMORAN	455	9	398	9	132	9	85	9
WALES	519		371		146		100	

YLL=YEARS OF LIFE LOST; PYL=POTENTIAL YEARS OF LIFE; SYLL= STANDARDISED YLL
SOURCE: Marlow, 1995

Table 8: Potential Years of Life Loss, Deaths from all Causes

Individual vs Areal Analysis

Because of the current study's ecological nature, it is necessary to recognise two inherent potential problems: the modifiable area unit problem and the ecological fallacy. The modifiable area unit problem states that the

findings of a given ecological study may change if the area of analysis changes, even though the underlying phenomena have not changed. Critics argue that the modifiable area units can be exploited to systematically alter results, irrespective of what the underlying individual analysis would reveal (Openshaw, 1984). In general, smaller and more homogeneous units are preferred. In Canada, census tracts are supposed, at least in theory, to be homogeneous in terms of general economic conditions, ethnicity and living conditions, although to what degree this actually holds true on the ground is a different matter (Anderson et al., 1997). Census tracts are used in the current study because they were the smallest (best) unit at which the data were available. For the purposes of this paper one should remain aware that the modifiable area unit problem exists, and that results may vary from similar work done at the census division or individual level.

The ecological fallacy has been understood in general terms since the ancient Greeks. Aristotle described it as confusing the characteristic of a group with those of its individual members. For example, the members of a hung jury might be described as being uncertain in their views, when in fact many members of most hung juries hold very strong views; it is just that the group as a whole cannot reach consensus. Such a case demonstrates that the collective expression of individual characteristics is not

necessarily congruent with the individuals the group contains (Schwartz, 1994).

The empirical evidence of the ecological fallacy in geography has existed for more than 40 years, since Robinson demonstrated that the correlation coefficient was not the same between individual and ecological level data (Schwartz, 1994). From this he concluded that individual relationships could not be inferred from correlations found in ecological or areal data. However Robinson's work was based on state-level data which itself suffers from the modifiable area unit problem. His results would have been considerably different, and probably more meaningful, if the work had been done at smaller, more homogeneous levels such as the census tract (Openshaw, 1984).

Most of the problems associated with the ecological fallacy surround inferring relationships to one level of analysis based on data from another. Some authors believe that if all individual variables could be specified, any group context would eventually disappear (Diez-Roux, 1998). This view is limiting since, as shall be discussed later, there are clearly some phenomena that cannot be studied or measured at the individual level. The problem in general is of ecological studies attempting to draw inferences about individual level phenomena and whether the community effect of the phenomena being studied is independent of the individual level (Diez-Roux et al., 1997).

Some authors view these macro-level variables as confounding and not causal in their own right. They believe that ecological analysis is the poor cousin of individual data and researchers only undertake such studies when individual level data are not available. Further, they can demonstrate that ecological studies will produce, in some cases, problems of internal validity or confounding. If this confounding does occur one must re-specify the ecological model, but if it is not clear what the confounding factors are then the ecological study is, in their view, rendered worthless. As a result, ecological studies are usually relegated to the less-esteemed hypothesis generating, as opposed to the more important hypothesis testing function that these authors believe can only be done at the individual level (Schwartz, 1994). Some go so far as to consider ecological findings to be potentially spurious, explaining only what could be better accounted for with additional individual data (Krieger, 1992). Yet, others criticise ecological studies as simply reproducing what is already known (uncovered at the individual level) and thus diverting attention from real progress at the individual level, where analysis attempts to establish causal relationships that ecological studies could never hope to attain (Hamnett, 1979).

In theory, the ecological fallacy is relatively easy to study. All one needs is access to individual level data that can be aggregated to an ecological level. In

practice, especially in Canada, privacy surrounding census and mortality information has made this extremely difficult (Openshaw, 1984). Ultimately ecological problems come down to questions such as, "is a person deprived because they themselves are deprived or because they live in a deprived area?" Census tract analysis cannot distinguish between deprived areas and deprived people. In other words, we do not always know how well an area's description applies to the individuals who live there (Openshaw, 1984). Consider the phenomenon whereby lower-class workers often cluster in deprived areas, while as individuals, they are not deprived (Fieldhouse and Tye, 1996). In general, measurement of deprived areas or deprived individuals will identify the same areas, but that does not necessarily mean that most deprived areas contain mostly deprived people. Deprivation at the individual level, although concentrated, tends to be much more pervasive in any given community than just a few deprived areas (Fieldhouse and Tye, 1996). Therefore, while working in the area of mortality and deprived areas, one never knows ultimately whether a death in a deprived area was of a deprived individual (Catalano, 1991).

This can lead to real problems if a government wants to implement area-based solutions based on ecological data, because by so doing a large segment of the individuals they are trying to target will be missed. For example, if the 10% most deprived areas in any given city are targeted for a programme, 50% of the deprived population of the city

could be excluded. Area targeting is, in general, an inexpensive shortcut (Hamnett, 1979), and if it is to be justified then it must be demonstrated that deprivation is spatially concentrated (Fieldhouse and Tye, 1996). In Fieldhouse's study of deprived people and deprived places, this was found not to be the case. While an ecological analysis found that multiple deprivations were concentrated in particular social groups and particular areas, when this was crosschecked with individual level analysis the strength of the relationship was found to be not nearly as great. While certain areas of inner city London did suffer from high levels of deprivation, in reality most areas contained some deprived individuals, making it extremely unwise to rely on a policy of targeting programmes spatially (Fieldhouse and Tye, 1996).

Medical geographers disagree fundamentally with many of these criticisms. They believe that neighbourhoods provide a milieu of individual and social interactions, in which individuals derive values, expectations and consumption habits (Diez-Roux et al., 1997). Further, they believe that geographic areal measures are useful surrogates for many variables for which individual level data are not available (Jones and Moon, 1993). Geographers and others believe that areal level analysis is good at catching net effects often missed by individual level analysis: there is a considerable difference in health impact between losing one's job and living in an area of

high unemployment (Catalano, 1991). Furthermore, the origins of any individual level variable may ultimately be well above or below the individual level: above in the case of the effect on an individual of mass unemployment, for example, or below at the level of genetic predisposition (Evans, 1994). Moreover, ecological studies are both less expensive and less time-consuming than individual level studies. They can often obtain more objective data than can individual studies, and many variables that are not available at the individual level are available at the ecological level (Morgenstern, 1982).

The origins of public health lie in the link between community environment and disease. However, with the advent of germ theory, organisms in effect became a substitute for community environments and the focus shifted to individual level analysis (Diez-Roux, 1998) to the point where it is now common for epidemiology texts to talk about drawing inferences to individuals. The term epidemiology itself is not concerned with the individual: "*epi*" meaning upon and "*demos*" meaning people, equating to health of populations. In effect, as the 20th century has progressed the model of disease causation has shifted from a vague holistic one that fitted the ecological model quite well, to a uni-causal germ theory that does not fit nearly as well with ecological analysis. Some authors have noted a model of multi-causal explanation of disease that works at

both the individual and the ecological level (Diez-Roux, 1998).

It is necessary to make a distinction between the immediate and ultimate cause of death, as both are equally valid in the study of disease causation. For example, a microbiologist studying lung cancer does not see the cause of death as based on SES or smoking behaviour, but as a problem at the molecular level, making the individual a divisible entity (Schwartz, 1994). Further, a focus on individual risk rather than social determination has shifted research attention away from macro or group level analysis. This tendency is sometimes known as the "doctrine of methodological individualism", and involves the erroneous assumption that facts about a society can be explained solely in terms of the cumulative facts about individuals. This philosophy naturally assumes that all analysis is best done at the individual level (Diex-Roux, 1998). Sociologists, of course, strongly disagree with this model, believing that individuals' characteristics are strongly influenced by the social groups to which they belong. Furthermore, these group characteristics affect outcomes such as mortality independently of individual characteristics (Diex-Roux, 1998). In this view, ecological analysis is not a poor substitute for individual study. If the inferences of the study are made about groups rather than individuals then ecological analysis is, in fact, the preferred method (Morgenstern, 1982).

Where social or cultural processes are of interest in a given study, here again the most useful unit of analysis may not be the individual, since inferences are drawn for society as a whole (Schwartz, 1994). For an example of how ecological study can be critical to solving a public health problem consider the case of a 1960 pellagra outbreak. When the problem was studied at the individual level researchers found that pellagra affected all members of the population regardless of their individual income. However when studied at the village level it was found that villages with low income suffered more because they were not able to import the necessary amounts of fruits and vegetables to combat the disease. The presence of fresh fruit and vegetables in a village by virtue of high average income was independent of any given individual's level of income. This case reminds us of the important fact that infectious disease affects not only the individual, but all members in a community (Diez-Roux, 1998). Authors who choose to ignore the fact that these findings could be made only by ecological analysis miss the contextual analysis and tend to fall into what others call the "individualistic fallacy". That is, the belief that individual data are sufficient to explain all social phenomena, including population health (Krieger, 1992).

Ecological successes aside, much ecological analysis of SES mortality is done for the pragmatic reason that SES data are not contained on most medical records,

making the matching of census-based SES data to individual health records common and necessary (Kreiger, 1992). Demystification begins when one acknowledges that aggregate data measure a different construct than individual data of the same name, because there can be little doubt that poor neighbourhoods, for example, exert different pressures on individual health than does individual poverty (Schwartz, 1994). Further, to assume individual level models are more accurate one must assume that they are more accurately specified. This is often the case but is not inherently true (Schwartz, 1994). For example, individual level studies often rely on surveys that are subject to response and recall bias as well as nay saying, and questions on sensitive issues such as abortion and alcohol consumption are not always answered truthfully (Schwartz, 1994). Sometimes these delicate issues can be more clearly addressed at the ecological level where individual embarrassment does not play such a large role.

Moreover, while it is certainly possible that risk can operate independently of area characteristics, it is also true that certain characteristics, especially concerning mortality, tend to cluster in low-income tracts (Anderson et al., 1997). The Alameda project studied both deprived people and deprived places. After its nine-year mortality follow-up, it found that fatality was 1.7 times greater in poor areas after controlling for a large number of individual level variables including income and other

socio-economic and behavioural characteristics (Schwartz, 1994).

In medical geography, social class has often been ignored in search of a more direct "spatial" causation. However, it is best to keep in mind that there is a large difference between spatial causation and spatial exacerbation, with the latter being much more likely and equally as important to the study (Hamnett, 1979). A comprehensive community health assessment should include measures at both the individual and the community level as a whole if it is to be effective (Goel et al., 1996). The ecological fallacy may be less of a threat to a study's findings if the association that was found in aggregate data has also been found in an individual level study (Catalano, 1991). In the end, it is the study's design that will dictate what conclusion and inferences can be drawn. If one wishes to make conclusions about causation at the individual level one would not be well served by an ecological study. However, if one wants to draw conclusions about population health in general in different communities based on socio-economic status, and if one is cautious when drawing conclusions, then ecological methodology is at least as good and in some cases better than individual level studies.

CHAPTER 4 DIFFERENCES IN LIFE EXPECTANCY BY SOCIO-ECONOMIC VARIABLES

This section presents the differing life expectancies based on a wide range of socio-economic variables. As described in the methodology section, all census tracts (CTs) in urban Ontario were ranked along different socio-economic dimensions. They were then placed into quintiles 1 through 5. A life table was created for each of the five quintiles, thus creating a life expectancy for each quintile and each socio-economic variable. The socio-economic variables were split into five general categories: economic, education, occupation, housing and social variables; in all 24 variables were tested. Let us now turn to the results of the differences in life expectancy generated by these 24 variables.

ECONOMIC

Percentage of Population Under the Low-income Cut-off (LICO) (Wilkins' Methodology)

Because this paper is closely modeled on the methodology and data of Wilkins' paper (Wilkins et al., 1991) it was thought prudent to start with a replication of his Canada-wide data for 1991 Ontario, based on the LICO variable and his methodology, which included the intra-city pre-sorting discussed earlier. This LICO variable stratifies the census tracts based on economic families that are classified by Statistics Canada to be below the low-income cut-off for their economic family size and size

of community. Wilkins believed this variable to be the best theoretically based variable for which to test SES mortality differential and as such tested this variable alone. It was suspected that Wilkins' intra-city sorting would lead to a problem of overmatching in the case of an Ontario study since by controlling for geography Wilkins was not allowing the full effect of SES to express itself in life expectancy differentials. For example, if northern Ontario has a low life expectancy and a low socio-economic status, in the Wilkins method this pattern will not fully reveal itself in the socio-economic analysis. Because the second part of our study will deal with the specific issue of life expectancies by city, it was thought best not to pre-sort by city except for this one variable. This would allow for direct comparison between Wilkins' Canada-wide analysis and the current study's Ontario analysis.

Even after carefully controlling for geography, Wilkins still found a pronounced monotonic mortality differential gradient. His 1971 data showed men in Q1 living 73.4 years and males in Q5 living 67.1 years: a difference of 6.3 years. For his 1986 data, Wilkins found males in Q1 living 76.1 years and males in Q5 living 70.4 years: a difference of 5.6 years, an overall reduction in the difference between 1971 and 1986 of 0.7 years. The same data show a slightly larger reduction for the same 15-year period for females. In 1971, females in Q1 lived 79.7 years and those in Q5, 76.9 years: a difference of 2.8

years. In 1986, females in Q1 lived 80.9 years and those in Q5 lived 79.1 years: a difference of 1.8 years, an overall decrease of one year. Therefore, in Wilkins' analysis, not only did females have approximately half the differential at the start of the period, but also in the 15 years between 1971 and 1986 they had a larger decrease of difference in life expectancy than did their male counterparts (see figure 6).

Wilkins' work with 1991 data was not presented in the same detailed fashion as his earlier work. Trends illustrated in earlier data continued with increased overall life expectancy but with the socio-economic life expectancies differentials stagnating.

In general, Wilkins had three findings:

1. Life expectancy in Canada was increasing.
2. The familiar monotonic gradient was found between quintiles measured by the low-income cut-off socio-economic variable.
3. While the gradient had been decreasing somewhat through the 1970s-80s, it appears the mortality

differential had begun to stagnate from the mid-1980s on.

LIFE EXPECTANCY BY L.I.C.O. (Wilkins Method)			
	TOTALS	MALE	FEMALE
Q1	79.84	77.39	82.16
Q2	79.14	76.63	81.46
Q3	79.04	76.00	81.84
Q4	78.17	75.01	81.06
Q5	76.78	72.97	80.47
DIFFERENCE			
(Q1-Q5)	3.06	4.43	1.69

Table 9: Life Expectancy by L.I.C.O.

The next step was to compare the results of the current study for Ontario only with Wilkins' existing data. In 1991 in Ontario, males in Q1, as sorted by this socio-economic variable, lived to 77.39 years while their counterparts in Q5 lived 72.97 years: a difference of 4.4 years, considerably less than Wilkins' 5.6 years. For females in Q1 life expectancy in Ontario in 1991 was 82.16 years, while for females in Q5 it was 80.47: a difference of 1.69, also slightly lower than Wilkins' gradient (see table 9 and figure 8). Whether these smaller gradients are a direct result of the findings being for Ontario only, or the fact that we are comparing 1991 data with 1986 data is not clear. What is clear is that the overall pattern continues to exist in Ontario in 1991 as measured by Wilkins' low-income cut-off variable. Using Wilkins' data and the current data, one can also see that the gradient for males, females and both sexes combined is completely monotonic.

This particular variable closely mirrors the earlier work done by Wilkins, differing only in respect to geographic coverage, and simply reiterates Wilkins' Canada-wide finding for Ontario in 1991. The challenge for the remaining variables is to see how they react when asked to demonstrate differences in life expectancy in a similar fashion.

Figure 8: Life Expectancy by L.I.C.O.

Low-income Cut-off (LICO)

Because Wilkins had taken such painstaking measures to control for geography in his methodology, I felt it was important here to re-run the calculation with all Ontario census tracts not pre-sorted by their original CMAs. This would make this low-income cut-off analysis directly comparable with all other variables in this study. It would also prove interesting to compare this result with that yielded by Wilkins' method in the hope of substantiating the claim that no significant geographic controlling was required for Ontario in order to produce meaningful socio-economic differences in life expectancy results. Again, it was believed that matching the socio-economic neighbourhoods by socio-economic variables alone, and not by city, was important because later in this study we are going to test for geographic differences using a

regression model. In addition, it was believed that overall socio-economic disparities between communities were not nearly as large within Ontario as within Canada as a whole.

LIFE EXPECTANCY BY L.I.C.O.			
	TOTALS	MALE	FEMALE
Q1	79.99	77.54	82.31
Q2	79.14	76.66	81.39
Q3	78.94	75.95	81.73
Q4	77.99	74.65	81.08
Q5	76.95	73.25	80.51
DIFFERENCE			
(Q1-Q5)	3.04	4.30	1.80

Table 10: Life Expectancy by L.I.C.O.

The differences between the two methodologies turned out to be inconsequential. The story was much the same, with female life expectancy in Q1 at 82.31 and in Q5 at 80.51: a difference of 1.80 compared to 1.69 using Wilkins'

methodology. For the males, the difference was 4.30 versus 4.43 using Wilkins method (see table 10 and figure 9). It was felt that these differences were so small that the rest of the study could be conducted in the manner originally planned, that is, without controlling for geography within Ontario and simply using the SES dimension to display differences in life expectancy, thereby making the socio-economic variable dimension the sole focus of the current study. The findings overall, in addition to their consistent differentials, show the monotonic gradient in all classifications (see figure 9) and again the male gradient is considerably steeper than the female gradient.

Figure 9: Life Expectancy by L.I.C.O.

Given our previous discussion regarding the ecological fallacy, and deprived places and deprived people, it may be of interest to give a sense of the make-up of some of the more extreme neighbourhoods included in the quintiles required to produce this analysis. For example, any census tract that had more than 20% of families under the low-income cut-off line was placed in quintile 5, the most disadvantaged census tracts. The highest percentage of low-income families in any census tract in Ontario was 64%, while the mean number of families under the low-income cut-off line in any census tract was approximately 9%, and any tract with less than 4.7% of residents living in low-income households made it into the most privileged quintile, Q1. From this type of distribution it is clear that any areal policies aimed at targeting deprived people by targeting deprived places would miss much of the target population.

Median Income

Much of the international literature on socio-economic mortality that uses income as its predictor variable

LIFE EXPECTANCY BY MEDIAN INCOME			
	TOTALS	MALE	FEMALE
Q1	80.45	78.59	82.14
Q2	79.31	76.91	81.59
Q3	78.61	75.74	81.33
Q4	78.04	74.55	81.34
Q5	76.38	72.29	80.25
DIFFERENCE			
(Q1-Q5)	4.07	6.29	1.90

Table 11: Life Expectancy by Median Income

defines it as median income. Median income does not have the strong theoretical foundation that low-income cut-off has in the sense that low-income cut-off controls for both family and community size whereas median income

does not. However, it is more generally available than the more specialised derived low-income cut-off variable. Any tract in Ontario in 1991 with a median family income lower than \$35,000 was placed in the quintile at most risk, Q5. The median income for census tracts in Ontario in 1991 was approximately \$47,000 and all tracts above \$62,000 median family income were placed in the most privileged quintile, Q1.

The mortality differentials calculated for this variable were: for males in Q1, life expectancy was 78.59 and for those in Q5 it was 72.29: a difference of 6.29. For females in Q1, life expectancy was 82.14 while in Q5 it was 80.25, giving a differential of 1.90 (see table 11 and figure 10).

Figure 10: Life Expectancy by Median Income

Given the large theoretical differences between this variable and the previous LICO variable the differences between these variables are extremely small. Again, we see the monotonic gradient through all quintiles with the overall gradient differential being much flatter for females than for males. If one's object was to select a variable with large differentials then this variable performed quite well, with the 6.29-year male differential ultimately proving to be one of the largest differentials of any of the variables tested.

Unemployment

The basic relationship between unemployment and poor health has been shown in numerous studies in different places and at different times. A clear Canadian example of this at the macro level is that life expectancy has increased throughout the 20th century with the exception of

the 1930s when the depression and unemployment wreaked havoc on the Canadian economy and its people (Health Surveillance, 1998a). Unemployment is generally classified into three types: frictional, which is often short term or voluntary; cyclical, which varies by industry and geography; and structural, which could be long-term. Each category implies a different type of social pressure and personal health outcome (Brenner and Mooney, 1983). The loss of one's job can mean different things for different people, with possible effects including loss of self-esteem, loss of income, loss of social mobility, an increase in stress, and an increase in poverty. It is the interaction of these effects that ultimately affects an individual's health and mortality.

In the past, unemployment has been tied to various diseases such as cardiovascular disease, cirrhosis of the liver, infant mortality, and suicide (Brenner and Mooney, 1983). At the ecological level, it is speculated that an individual's reaction to unemployment varies according to the rate of unemployment in his or her community. For example, high rates of unemployment in a community can invoke two contrary responses when an individual loses his or her job: they may feel blameless and that it is not their fault; but they may also feel under much more stress because in those circumstances it will be difficult to find another job. Therefore, it is speculated that it is often one's reaction to unemployment as opposed to the

unemployment itself that affects one's health. These effects on health are often measured in terms of mental distress, gauged by admissions to psychiatric hospitals or numbers and type of drugs being prescribed (Brenner and Mooney, 1983). Job loss can lead, in many cases, to some sort of depression in the individual that will affect the entire family. Given the link between mental illness and mortality it is not surprising that ultimately unemployment and mortality are also linked (Catalano, 1991).

LIFE EXPECTANCY BY THE UNEMPLOYMENT RATE			
	TOTALS	MALE	FEMALE
Q1	79.90	77.35	82.21
Q2	79.37	76.99	81.51
Q3	78.72	75.63	81.62
Q4	78.10	74.85	81.15
Q5	76.82	73.12	80.45
DIFFERENCE			
(Q1-Q5)	3.08	4.23	1.76

Table 12: Life Expectancy by the Unemployment Rate

There are three main explanations for the link between unemployment and mortality. First, job loss is a direct cause of stress. Second - the reverse causation argument - those

individuals in poor health lose their jobs, they do not necessarily become ill after

losing their jobs. Third, there is a train of events that links unemployment to lower SES and the correlation between lower SES and decreased overall health and increased mortality (Moser et al., 1984). While economic instability affects all social strata with loss of social status and income, it may affect those at the lowest end of society more dramatically because they have less maneuverability in

these areas (Brenner and Mooney, 1983). Studies have found that unemployment raises mortality for all individuals but, even after controlling for SES, some 20-30% of the SES mortality remains, meaning that lower SES individuals are at greater health risk from unemployment than their higher SES counterparts (Moser et al., 1984).

Ecological level studies also show that those who retain their jobs in a community or organisation plagued by unemployment are subject to many more stresses such as overwork, increased supervision, low morale and fear of job loss (Brenner and Mooney, 1983). This moves the argument slightly away from unemployment itself to a more general problem of economic insecurity, which has been operationalised as anticipated unemployment. Some data have shown that the anticipation phase might be as harmful to one's health as the actual unemployment (Jerrett et al., 1998). For this and other reasons unemployment studied at the ecological level seems to be a valid theoretical construct, given that individuals can be affected not only by their own employment status, but also by that of their community and/or family.

The mortality differential results yielded by the current study's unemployment analysis found the familiar monotonic gradient, with males more affected than females. For males in Q1, the quintile of lowest unemployment, life expectancy was 77.35 years, while in Q5 it was 73.12 years: a differential of 4.23 years. For females, it was 82.21 in

Q1 and 80.45 in Q5: a difference of 1.76. In general, the unemployment socio-economic variable performed in much the same way as other economic variables tested so far (see table 12 and figure 11).

Figure 11: Life Expectancy by the Unemployment Rate

Percentage of Population Participating in the Paid Labour Force

In recent years the Canadian government has done much to revamp the unemployment insurance system, including the rather cynical renaming of it as the Employment Insurance

LIFE EXPECTANCY BY LABOUR FORCE PARTICIPATION			
	TOTALS	MALE	FEMALE
Q1	79.20	76.88	81.29
Q2	78.87	76.19	81.39
Q3	78.47	75.60	81.21
Q4	78.54	75.42	81.43
Q5	77.36	73.67	80.81
DIFFERENCE			
(Q1-Q5)	1.83	3.21	0.48

Table 13: Life Expectancy by Labour Force Participation

System. Critics argue that the net effect of these changes has been to do nothing for the unemployed except define them away. Thus the number of people

actually unemployed remains much the same, but the reported number or rate appears much smaller. Although this phenomenon was not as significant in 1991, the year of the current data set, it will become increasingly pronounced when comparisons are made with more current Canadian data in the future. Therefore, it was felt that it might be useful to look at a more general workforce statistic such as percentage of people participating in the paid workforce. Of course this variable, in common with all others, is not without its problems, most of which stem from the fact that not all people want to or can participate in the paid workforce. Single parents, retired people and a host of other groups choose not to participate in the paid workforce, and are not necessarily at any economic or health risk.

Any tract with a participation rate of over 78% was included in Q1. The median participation percentage was approximately 70% and any tract falling below 63% fell into the bottom quintile. Given that the entire participation percentage falls in a narrow range between Q1 and Q5, may in part explain its rather poor performance in showing differences in life expectancy.

For males in Q1, life expectancy was 76.88 years, and in Q5 it was 73.67 years: a differential of 3.21 years, the smallest differential of any variable tested so far. For females, the situation was extremely similar, showing a life expectancy of 81.29 in Q1 and 80.81 in Q5: a

differential of only 0.48 years, again the smallest of any variable tested so far. The gradient remained monotonic for the males but for females it was virtually flat, with a slight drop off in Q5 (see table 13 and figure 12).

Figure 12: Life Expectancy by Labour Force Participation

A difference of only 0.48 years between all five quintiles meant that a monotonic gradient could not be sustained. Although unemployment rate may be a problematic indicator it appears that replacement by an indicator based on participation rate in the workforce is not advisable given the lack of performance of the data here. Perhaps another variable to measure workforce involvement could be devised later.

Percentage of Income from Government Transfers

The final income SES variable used was percentage of income in a given census tract derived from government transfers, which include employment insurance benefits, social assistance and pension payments. It has often been thought that differences in SES measured by income are caused not by the absolute amount of income derived by an individual or a family, but by the source of that income (i.e. whether it came from government sources or from

LIFE EXPECTANCY BY PERCENTAGE OF INCOME DERIVED FROM GOVERNMENT TRANSFERS			
	TOTALS	MALE	FEMALE
Q1	80.13	78.13	81.89
Q2	79.45	76.78	81.91
Q3	78.58	75.58	81.44
Q4	78.31	75.17	81.29
Q5	76.54	72.69	80.19
DIFFERENCE			
(Q1-Q5)	3.59	5.44	1.71

Table 14: Life Expectancy by Percentage of Income Derived from Government Transfers

working, perhaps at a low-wage job). Of course working in a low-wage job has both benefits and detriments as opposed to deriving one's income from a government transfer.

For example, those working in low-wage jobs are thought to have higher self-esteem because they are able to earn a living and be self-sustaining. However, many low-wage jobs tend to be highly stressful and often quite dangerous in nature, which could counterbalance any helpful effects that may come about from increased self-esteem.

The results for this variable's life expectancy differentials were: for males in Q1 78.13 years, and for males in Q5 72.69 years: a differential of 5.44 years, the

second largest after median income. For females, it was 81.89 in Q1 and 80.19 in Q5: a differential of 1.71, consistent with most other economic differentials (see table 14 and figure 13). Therefore, for reasons that may be artifactual, but are at least unclear, this variable appears to affect males more than females, over and above the normal differentials between the sexes.

Figure 13: Life Expectancy by % of Income Derived from Government Transfers

In summary then, the economic variables tested here performed much as expected. That is, mortality differentials were robust with consistent monotonic gradients. The results that stood out from the pattern were the high male differentials in median income and the relatively high male differentials in government transfers. On the other hand, there was a relatively modest display of mortality differentials by the participation index, especially for females. Male/female differentials were consistent throughout, with the male differential around 4

to 5 years on average, and the differential for females often ranging between 1.5 and 2 years. Almost all of the variables tested provide fairly clear life expectancy differentials. However, the variables most commonly used in the literature - median income and LICO as used by Wilkins - seem to be among the best performers, and these findings would tend to support their continued use.

EDUCATION

As noted in the literature review, formal education has often been considered a valid SES indicator for a number of reasons. Some studies, including Kitagawa and Hauser and a recent study conducted in the Netherlands, have found it to be a much better indicator than occupation (Stronks, 1996). Originally, it could be applied to women who were often not in the workforce and therefore not easily classified by occupation. The same applies to retired individuals and the unemployed. Education also remains relatively constant as it is usually completed in young adulthood. Therefore, while correlating well with income and occupation, education suffers less from the possibility of health selection, or low SES due to a downward drift because of poor health (Feldman et al., 1989). Further, chronic morbidity at an early age will influence both a person's education and their ultimate mortality (Fox et al., 1985).

It has been shown that an individual's education affects not only the amount of income they can earn but also the amount of pollution they are exposed to, and the amount of health care and health professionals to which they have access. This is because education can give individuals knowledge about health threats and allows them to adopt what some authors have called "defensive behaviours" (Evans, 1994). It has been found that less educated individuals participate in more health adverse behaviours, such as smoking, obesity, high cholesterol levels, high blood pressure, and have more overall health risks. However, even when these known factors are controlled for the educational mortality differential gradient persists (Feldman et al., 1989).

Education has been correlated with certain causes of death. In the case of breast cancer the relationship is reversed, an indication of a disease where the defensive behaviours are not yet well understood. However, in the case of coronary disease, where the aetiology is better understood, there has been a dramatic decrease in coronary heart disease among the highest educated groups with a correspondingly lower rate of decrease among the less educated (Brenner and Mooney, 1983).

The measurement of SES by education is not without problems. First, education attainment and necessity has changed greatly during the course of this century. Correspondingly, educational opportunities and requirements

vary dramatically by age cohort. The elderly are more likely to have received less education, but this fact is less likely to affect their SES as measured by other variables. Second, in many industrialised countries there is increasing homogeneity in the amount of education attained by most of societys members, although the education differentials still seem sufficiently large to be manifested in mortality differentials (Liberatos et al., 1988).

The role played by education in determining health has changed significantly in the last two decades. One study looking at mortality differential by education in 1960 and again in 1984 found that differentials between low and highly educated groups had increased by over 50%. The authors concluded that although both groups had a lower mortality rate the educated group's mortality had dropped much faster than that of the lower educated cohort. The single biggest contributing factor was the high SES group's dramatic reduction in heart disease (Feldman et al., 1989).

From the census data available for this research, I was able to devise three measures of educational attainment.

Percentage of Population with less than High School Education

The first educational variable tested was a calculation based on the percentage of individuals (over the age of 15)

in any census tract that had not completed a high school education. The census tracts were then arranged in the

LIFE EXPECTANCY BY LESS THAN A HIGH SCHOOL EDUCATION			
	TOTALS	MALE	FEMALE
Q1	80.08	77.47	82.32
Q2	79.42	76.83	81.75
Q3	78.46	75.54	81.21
Q4	77.88	74.79	80.83
Q5	77.19	73.52	80.86
DIFFERENCE			
(Q1-Q5)	2.89	3.95	1.46

normal way (highest to lowest) and placed in the appropriate five quintiles, the median number being approximately 35% of residents of any given tract being

high school drop-outs. The range between the census tracts is extremely large, from 3% of individuals in a tract

LIFE EXPECTANCY BY LESS THAN A HIGH SCHOOL EDUCATION

Figure 14: Life Expectancy by Less than High School Education

being high school drop-outs, to 69%. Males in the highest educated quintile, Q1, live, on average, 77.47 years and those in Q5 live 73.52 years: a difference of 3.95 years. For females in Q1, the result was 82.32 years, and for

those in Q5 80.86 years: a difference of 1.46 years (see table 15 and figure 14).

The differences here were similar to, if marginally smaller than, what was generally found by most of the income variables. The gradient and gender differentials were also consistent with those found in most other variables.

Beyond High School

The claim is often made that a high school education

LIFE EXPECTANCY BY EDUCATIONAL ATTAINMENT IN ADDITION TO HIGH SCHOOL			
	TOTALS	MALE	FEMALE
Q1	80.02	77.34	82.33
Q2	79.39	76.25	81.79
Q3	78.35	75.45	81.08
Q4	77.85	74.69	80.88
Q5	77.39	73.88	80.84
DIFFERENCE			
(Q1-Q5)	2.63	3.46	1.49

Table 16: Life Expectancy by Educational Attainment in addition to High School

is no longer sufficient for success in the modern Canadian labour market.

To operationalise this variable at the ecological level, we took all

the high school graduates, who had completed at least one other degree or certificate: for example college diplomas, university degrees and trade or industrial certificates.

Here again we found the familiar monotonic gradient. The males in Q1 lived 77.34 years, while those in Q5 lived 73.88 years: a difference of 3.46 years.

The figures for females Figure 15 were 82.33 years and 80.84 years respectively: a difference of 1.49 years. These results paralleled closely the results found in the previous education variable (see table 16 and figure 15).

Figure 15: Life Expectancy by Educational Attainment in addition to High School

University Graduates

The final educational variable tested was the percentage of university graduates in a census tract. Neighbourhoods in Ontario ranged from 0% to 59% in their percentage of residents completing a university education, with the mean being 30%.

For this variable, males in Q1 lived 77.13 years and those in Q5 lived 73.93 years: a difference of 3.20 years. The figures for females were 82.31 years and 80.72 years respectively: a difference of 1.59 years (see table 17 and figure 16).

LIFE EXPECTANCY BY UNIVERSITY GRADUATES			
	TOTALS	MALE	FEMALE
Q1	79.90	77.13	82.31
Q2	79.33	76.55	81.85
Q3	78.34	75.34	81.14
Q4	77.92	74.97	80.78
Q5	77.33	73.93	80.72
DIFFERENCE			
(Q1-Q5)	2.57	3.20	1.59

Table 17: Life Expectancy by University Graduates

For males, university graduation displayed a slightly smaller than average difference in life expectancy, whereas for females it was slightly greater. However these differences were thought

to be quite small and in all likelihood not significant, which would lead to the conclusion that all the educational variables tested here performed in much the same way.

LIFE EXPECTANCY BY UNIVERSITY GRADUATION

Figure 16: Life Expectancy by University Graduation

That is to say, they all showed a life expectancy differential, but the difference between the three

variables was not great enough to warrant the selection of one variable over another. The choice of educational variable should therefore depend on the specific needs of the analysis being conducted. It should also be pointed out that the educational variables behaved in much the same way as the economic variables tested before.

OCCUPATION

Of all the major classifications tested in this study, occupation was by far the most disappointing in its ability to show life expectancy differentials. Because of the ecological nature of the study, we were not able to replicate closely the work of many of the landmark occupational studies such as Black or Kitagawa and Hauser. These earlier works were done at the individual level, where occupation could be garnered for each individual and then carefully placed into individual categories. Occupation at the ecological level is given in much more general terms and therefore the occupations cannot be as finely graded as would have been necessary to replicate some of the earlier occupational studies.

Periodically, sociologists and others do public opinion surveys to ascertain the relative esteem given to different occupations. Although there are several dozen occupational classifications on a Statistics Canada census long form it is not possible to correlate these with the available

public opinion survey occupational scoring systems. In general, however, occupation affects SES status in two distinct ways: public esteem and monetary benefits (Liberatos et al., 1988).

Furthermore, unlike most SES classifications, occupation can pose direct mortality and morbidity hazards, as some jobs involve inherent dangers, ranging from environmental toxins to stress, which can directly or indirectly affect life expectancy. Some job related hazards are less well known. Syme has shown that jobs where demands placed on workers were unpredictable and gave individuals little latitude, while also undervaluing their skills, tended to be very high in rates of heart disease. While Syme's study was conducted on bus drivers, the same general conclusions can be drawn from the Whitehall study with regard to lower SES civil servants, who often have less control of their own work environment than do their superiors (Hertzman et al., 1994).

One of the problems with occupational classification is that it may or may not be associated with income. In the *Black Report*, for example, while the gradient was clear for occupational classifications, when this was converted to income there was no step-wise gradient. With the success of trade union movements in much of the industrialised west, it is not unusual for someone performing what was previously thought to be a rather low SES ranking job to be extremely well paid, thus making the

occupational classification incongruent with income. Underscoring one of the reasons for testing a variety of different SES variables is that we may indeed be testing slightly different constructs of the same phenomenon.

One final methodological problem with occupational classification is that in cross-sectional studies, if the occupational class for a total population is taken from census data, but the occupational class for mortality is taken from death certificate data, then it can be subject to the numerator/denominator bias mentioned earlier. This leads to potential calculation problems with regard to mortality rates where numerators do not match denominators.

Because of problems of overall job classification, and the fact that we are working at an ecological rather than an individual level, the best that could be attained in this study was to rank jobs into broad general categories. In this case, they were classified as primary industry, manufacturing jobs, and quaternary sector jobs, that is those jobs in the information, health science and service fields.

The primary industry group, which includes hunters, farmers, fishers, trappers, etc., was used in both the Jerrett and the Health Surveillance studies. This group was seen as being potentially negatively influenced by their occupational classification because of the cyclical nature of their work, which correlates closely to the

economic insecurity argument already made, and the potential dangers they face at the work place.

The second occupational classification, manufacturing, has been used in previous work as a surrogate for relatively safe, secure and high paying employment. As such, a high percentage of manufacturing jobs in any area should have an overall benefit to the area's life expectancy. However, the data being studied here is from 1991, and since then much has happened to the manufacturing base in Canada, including the full effects of the Free Trade Agreement. Now, manufacturing jobs are seen as increasingly unstable under the pressures of globalisation and free trade. Even those who continue to hold manufacturing jobs do so in an environment of some economic uncertainty. Whether manufacturing jobs in Canada will continue to be seen as the safe, stable, high paying protectant they have been in the past remains to be seen, and may prove an interesting direction for future analysis of differential mortality.

The third and final classification of workers studied here is that of quaternary sector workers. To operationalise this classification from the available census data a definition was taken from Dave Ley's work on the occupational classification of those he identified as gentrifying Canadian inner cities (Ley 1986), including occupations such as teachers, hospital workers, administrators, and insurance sales people. In short, they

tend to be relatively safe, high paying jobs in sectors that continue to grow in a modern economy. They also tend to require more education and allow greater employee flexibility than do many old style manufacturing and primary industry jobs, and there is a consequent higher overall job satisfaction for many employees working in this sector. The results for the three occupational classifications are as follows.

Quaternary Sector

LIFE EXPECTANCY BY QUATERNARY WORKFORCE PARTICIPATION			
	TOTALS	MALE	FEMALE
Q1	80.06	77.34	82.39
Q2	79.15	76.21	81.85
Q3	78.25	75.43	80.88
Q4	78.02	74.86	81.06
Q5	77.38	74.08	80.65
DIFFERENCE			
(Q1-Q5)	2.67	3.27	1.74

Table 18: Life Expectancy by Quaternary Workforce Participation

When the census tracts were ranked by the percentage of employees in the quaternary sector the results were much the same as for the many economic and educational variables, with the familiar monotonic gradient for males and females. Any tract containing more than 43% of the workforce in the quaternary sector was placed into Q1. The median for the province of Ontario was 33% and tracts below 23% were placed in the least advantaged quintile, Q5. For males in Q1, the average life expectancy was 77.34 years, with this figure dropping to 74.08 years for those living in Q5 census tracts: a difference of 3.27 years. For females, the average life expectancy was 82.39 years for Q1 and 80.65

years for Q5: a difference of 1.74 years (see table 18 and figure 17).

These results closely mirror many of the other variables tested so far.

Figure 17: Life Expectancy by Quaternary Work Force

Manufacturing Jobs

Neither manufacturing nor primary jobs behaved as would have been initially predicted from the literature reviewed. The results for manufacturing were generally mixed, showing no pronounced life expectancy differential when census tracts were ranked based on percentage of manufacturing jobs. While the distribution of manufacturing jobs did tend to stratify amongst the census tracts, no discernible

differences in life expectancy could be found (see figure 18).

One possible explanation for this is that manufacturing jobs are actually a neutral SES health influence, neither protective nor hurtful for overall life expectancy. The second possible explanation is that manufacturing neighbourhoods in Ontario could be in a period of transition. As hypothesised here and elsewhere, manufacturing jobs were initially protective through their high paying and stable nature. However, they have become increasingly unstable given the pressures of globalisation and the Free Trade Agreement, making them somewhat detrimental to an individual's health according to an economic insecurity argument. What may have been captured in this 1991 data is a transition phase, where manufacturing has gone from being protective in earlier periods to a point where it may now be negatively correlated with mortality differentials with data dating from the mid-1990s onward.

For the time being these results suggest that anyone wishing to use the percentage of manufacturing jobs as a socio-economic variable for studying differences in life expectancy should do so with extreme caution. It should not be assumed that what has been considered a protectant in the past will continue to be so in the future.

Figure 18: Life Expectancy by Manufacturing Workforce Participation

Primary Industry

The final group studied was the percentage of the workforce involved in primary industries. While the results showed a slightly negative gradient (i.e. primary industries are not in fact dangerous to health but are slightly protective), these results were deemed artifactual and not significant. This was decided not because of actual differences in life expectancy, but because of the extremely small number of people involved in these industries living in urban Ontario and the rather uneven distribution of the few that do. Previous ecological studies that have used this variable were not just for census metropolitan areas, but were for the entire provinces of Ontario and Alberta, thus capturing all the rural residents as well as those in the major metropolitan areas. Because it appears that the vast majority of people

involved in these industries live in rural areas, there are simply insufficient numbers to elicit meaningful results from a study of CMAs only. In terms of empirical evidence of the scope of the problem, almost 90% of all census tracts in the study contained less than 1% population involved in this line of work, clearly insufficient for any meaningful result in a quintile study of this type. It is simply not conceivable that 1% could have a meaningful effect on the health of the rest of the census tract population. It is therefore recommended that studies of metropolitan areas should not use primary industry as a socio-economic variable for measuring differences in life expectancy if the study is conducted at the ecological level.

Given that the occupation measurement has become something of a cornerstone of SES mortality differential studies, this category performed rather poorly here with only quaternary sector employment providing any meaningful results. Part of the problem was that we were studying only metropolitan areas, thereby ruling out primary industry workers, while another important factor was the neutral effect of the manufacturing sector, indicating either no effect or a socio-economic variable in transition from a positive protective effect to a negative one. It may be simply that working at the ecological level in occupation is not one of the better choices if other SES variables are at hand.

Even when working at the individual level, one must keep in mind the numerator/denominator bias discussed earlier. This can mean that cross-sectional as well as ecological studies of occupation may be problematic, leaving longitudinal studies as the only reliable method in which to use occupation, as was the case in the Whitehall study.

HOUSING

While housing is rarely used by itself, it is often used in conjunction with other socio-economic variables to form impressions about individuals or neighbourhoods' living standards. In ecological studies housing has the potential to play a unique role because of its fixed nature and its relationship to place. In order to look at differences in life expectancy in relation to housing three different housing variables were derived from available census data. They represent three different dimensions of housing: tenure, overcrowding and overall condition of homes in the census tracts studied.

Ratio of Renters versus Home Owners

Home ownership has been in the past, and to some extent continues to be, a major goal of many Canadians. It is promoted by the government of Canada through CMHC mortgage insurance and various other housing programmes. While home ownership among Canadians is high relative to

many other industrial countries, it is still beyond the reach of many. Therefore, those who attain home ownership are seen to be of higher socio-economic status, and neighbourhoods with a high percentage of home ownership are generally seen to be higher socio-economic neighbourhoods. As such they should portray improved health outcomes. Furthermore, because of their large fixed financial investment, homeowners have a tendency to relate differently to their neighbourhoods, and to take a more active interest in what goes on in and around their homes. Therefore, neighbourhood tenure patterns can manifest themselves in many ways beyond the homes themselves.

To test whether any of this makes a difference to life

LIFE EXPECTANCY BY HOUSING TENURE			
	TOTALS	MALE	FEMALE
Q1	79.45	77.29	81.61
Q2	78.72	76.34	81.07
Q3	78.71	75.88	81.35
Q4	78.25	74.87	81.41
Q5	77.40	73.46	80.92
DIFFERENCE			
(Q1-Q5)	2.05	3.83	0.69

Table 19: Life Expectancy by Housing Tenure

expectancy a ratio was derived for each census tract of renters versus homeowners. Home

ownership was generally widely distributed

throughout the census

tracts with rates

ranging from less than 1

renter to 100 home owners in the lowest tracts to over six times as many renters as home owners in the highest rental tracts. Tracts that had 137 renters to 100 homeowners were placed in Q5, the least protective quintile, while those

tracts containing only 15 renters per 100 home owners were placed in the most protective quintile, Q1.

The mortality differentials generated from this variable are as follows. Males in Q1 lived 77.29 years while those in Q5 lived 73.46 years: a difference of 3.83 years. Females in Q1 lived 81.61 years, while those in Q5 lived 80.92 years: a difference of 0.69 (see table 19 and figure 19). For the males, this variable performed as many others, with the familiar monotonic gradient and an average amount of mortality differential compared to the other variables tested. For females, the relationship was practically non-existent given the small Q1 to Q5 differentials and the irregular pattern of the quintile results between Q1 and Q5.

Figure 19: Life Expectancy by Housing Tenure

Given that females generally have a much smaller differential, it could be hypothesised that some of the less affected variables that show small differentials for males would show no differential for females, this is somewhat surprising considering that many of the least advantaged economic families are headed by lone females and, given the economic and therefore housing disadvantage in which this group generally finds itself, we would expect the female gradient to manifest itself here.

Overcrowded Housing

Statistics Canada defines overcrowded housing as housing that contains more than one family member per room. This is an arbitrary and cultural decision as in Britain the corresponding number is 1.5 persons per room, showing that more crowded housing is culturally more acceptable there (personal correspondence D. Bennett). This variable did not perform well in showing differences in life expectancy, for many of the same reasons that came to plague the analysis of primary industries. The highest overcrowding index for any census tract in Ontario was 0.7, far below Statistics Canada's threshold of 1.0 persons per room. Therefore, it is safe to conclude that there is no census tract in Ontario where families, on average, live in overcrowded conditions, reflecting perhaps the overall high quality of housing that Ontario residents enjoy. At the low end of the overcrowding index were census tracts that

started from 0.3 persons per room. These densities were not sufficiently detrimental or beneficial to any significant segment of the population to display a difference in life expectancy. The results displayed were practically random or flat, leading to the conclusion that this type of analysis cannot be done in a Canadian ecological context.

However, this is not to disregard the problems of individuals in overcrowded housing. Although no tracts were found to be on average overcrowded, many families in poor economic circumstances find themselves in extremely overcrowded housing conditions. There is little doubt that these overcrowded conditions cause problems in terms of both stress and the spreading of infectious disease. However, as these households cannot be isolated at even the small ecological level of the census tract, this analysis is best done at the individual level.

Percentage of Homes in Need of Major Repair

LIFE EXPECTANCY BY CONDITION OF HOUSING STOCK				are trained to appraise the overall quality of the dwellings that they survey and to place dwellings in three categories: those in
	TOTALS	MALE	FEMALE	
Q1	79.90	77.52	82.06	
Q2	79.40	76.63	81.98	
Q3	78.51	75.64	81.17	
Q4	77.97	74.45	81.35	
Q5	76.99	73.54	80.27	
DIFFERENCE				
(Q1-Q5)	2.91	3.99	1.79	

Table 20: Life Expectancy by Condition of Housing Stock

need of no repairs, those in need of minor repairs, and those in need of major repairs. It is those in need of major repairs that will concern us here.

It is theorised that areas with a large number of homes in need of major repairs may be disadvantaged in a number of other areas. Either the home owners are

sufficiently economically deprived that they are unable to perform the repairs, or they live in rental properties where property owners choose not to make these repairs and the economic circumstances of the tenants do not permit them to move elsewhere. It was theorised earlier that people who own their homes take an active interest in all aspects of their community. It is also possible that the opposite could be true for neighbourhoods where a large percentage of homes are in need of major repair, demonstrated clearly by the U.S. urban phenomenon of building abandonment and associated neighbourhood decline. In general, this variable performed extremely well in showing differences in life expectancy. Any tracts that had between 10% and 40% of its homes in need of major repair were placed in Q5, and those with less than 2% of homes in need of major repair fell into the most protective quintile, Q1. For males in Q1 life expectancy was 77.52 years, while for those in Q5 it was 73.54 years: a differential of 3.99 years.

Figure 20: Life Expectancy by Condition of Housing Stock

For females in Q1, life expectancy was 82.06 years, and for those in Q5 it was 80.27 years: a differential of 1.79 years (see table 20 and figure 20). These were similar degrees of mortality differential as had been witnessed in many of the other variables. In terms of housing this is clearly the best performing variable, being slightly so for males and clearly so for females. In fact, for females it reveals one of the highest differential life expectancies of any variable in the entire study. In terms of life expectancy for males, the two housing variables performed as did many of the other variables in this study. In the case of females only the repair variable performed as expected. Indeed, the repair variable appears to serve as a good indicator of the quality of housing in a given census tract and in turn of the overall life expectancy of the residents therein. Therefore, it is concluded that this

is the best housing variable for producing SES mortality differentials, and its use is recommended for studies of this kind.

SOCIAL

Ratio of Children Born to Single Mothers

This variable ranks census tracts according to a ratio of children born in and out of wedlock. Families headed by women have long been known to be at greater risk of many socio-economic and other related problems. It is hypothesised here that those residents of neighbourhoods containing a large percentage of out-of-wedlock births will also be characterised by shorter life expectancy. The

LIFE EXPECTANCY BY RATIO OF CHILDREN BORN TO SINGLE MOTHERS			
	TOTALS	MALE	FEMALE
Q1	79.95	77.57	82.09
Q2	79.31	76.32	82.04
Q3	78.67	75.59	81.56
Q4	77.84	74.80	80.73
Q5	76.57	72.95	80.09
DIFFERENCE			
(Q1-Q5)	3.38	4.61	2.00

Table 21: Life Expectancy by Ratio of Children Born to Single Mothers

results are much as expected, with the monotonic gradient and significant Q1 to Q5 differentials.

Any tract that had below 2% of children born out of wedlock was placed in the most

protective quintile, Q1, while tracts between 11% and 42% were placed in the quintile that showed the most socio-economic disadvantage according to this variable, Q5. The differential life expectancies were as follows: males in Q1 had a life expectancy of 77.57 years and males in Q5 72.95

years: a differential of 4.61. For females the figures were 82.09 years and 80.09 years respectively, a difference of 2.00 (see table 21 and figure 21). Overall, these were some of the largest mortality differentials found. In fact, for females the Q1 and Q5 differential in this variable was only a few days short of the largest difference in life expectancy for females.

Figure 21: Life Expectancy by Ratio of Children Born to Single Mothers

These results should come as no surprise, since single motherhood often means a truncating of education and extremely limited employment opportunities, caused by a combination of the lack of education and limited access to day-care. Often, the housing that can be afforded by these individuals is at best adequate.

Lone Parent Families

This variable calculates the percentage of families in a census tract that are headed by only one adult. Although the census makes no differentiation between male and female

LIFE EXPECTANCY BY LONE PARENT FAMILIES			
	TOTALS	MALE	FEMALE
Q1	79.64	77.46	81.83
Q2	79.53	76.79	82.05
Q3	78.84	75.78	81.65
Q4	78.04	74.72	81.10
Q5	76.71	73.07	80.14
DIFFERENCE			
(Q1-Q5)	2.93	4.38	1.68

Table 22: Life Expectancy by Lone Parent Families

lone parents, it is well known that the overwhelming majority of these families are headed by women. This variable differs slightly from the previous one in that it includes not only children born out of

wedlock but also families affected by divorce, separation and widowhood. Family break-up has been demonstrated to severely affect the socio-economic status of the individuals involved: a recent Statistics Canada study suggested that the primary reason for economic families falling into poverty was not job loss but divorce.

Tracts with between 18% and 50% lone parent families were placed in the most disadvantaged quintile, Q5, and any census tracts that had less than 8% of its economic families headed by lone parents was placed in the top quintile, Q1. Life expectancy for males was 77.46 years in Q1 and 73.07 years in Q5: a Q1 to Q5 differential of 4.38 years; for females in Q1 the life expectancy was 81.83 years and in Q5 it was 80.14 years: a mortality

differential of 1.60. These differentials were among the largest in this study (see table 22 and figure 22).

Figure 22: Life Expectancy by Lone Parent

Number of Children at Home

This variable measures the number of never married children still living at home with their parent or parents. In the Alberta study the number of children at home was found to be negatively correlated with life expectancy. The authors of that study do not make clear why a greater number of children at home should place someone at SES risk, although there has been an overall trend in recent years for individuals of higher socio-economic status to have fewer children. Therefore, following the Alberta example, any census tract that had between 1.5 and 2 children still at home was placed into the at risk Q5, while those averaging less than 0.9 were placed in Q1.

By placing the census tracts into these quintiles we found a strong reverse gradient, especially in males, the exact opposite of what was found in the Alberta study (see figure 23). In this case, those with the smallest number of children at home were seen to be at most risk. The authors of the Alberta study do not make clear why they chose to include this variable, nor where else in the literature they found this variable used. We have found no other cases of this variable being used in the literature. Therefore, since we have no strong theoretical underpinning for this variable, and two ecological studies in different provinces in Canada in 1991 show opposite results, we conclude that this variable should be used only with extreme caution, if at all.

Figure 23: Life Expectancy by Number of Children Living at Home

There is, however, some evidence that the number of children an individual woman will have is based ecologically by the type of census tract in which she lives, as opposed to her individual socio-economic status. A study of working class women who lived in non-working class tracts showed that they had the same number of children as their non-working class neighbours. That is, when working class women were the minority in their census tract their childbirth patterns replicated those of the non-working class majority. Working class women who lived in working class tracts had on average 0.3 more children than their working class compatriots who lived in non-working class tracts (Krieger, 1992). This suggests that childbearing does bear some relationship at both the individual and ecological levels, but how this relationship affects life expectancy cannot be determined from this study, given the contrary findings from the Alberta report. Perhaps this variable would perform more consistently at the individual level.

Marriage Ratio

In this variable, the number of married individuals was compared to the number of unattached individuals to determine a marriage ratio for each census tract. As marriage is generally accepted in the literature as a protectant, those tracts with high marriage rates were expected to have higher life expectancies. This phenomenon

LIFE EXPECTANCY BY MARRIAGE RATES			
	TOTALS	MALE	FEMALE
Q1	79.49	77.41	81.59
Q2	79.05	76.47	81.58
Q3	78.75	75.98	81.37
Q4	78.36	75.23	81.21
Q5	76.59	72.38	80.48
DIFFERENCE			
(Q1-Q5)	2.90	5.03	1.11

Table 23: Life Expectancy by Marriage Rates

has been especially true for males. The link has been shown as a direct link between marriage, especially in males, and risk-taking behaviour, since the female spouse is seen to give much needed social support and to encourage a healthier lifestyle than would be adopted by the male should he have remained single. It is further theorised that persons of low income may be especially vulnerable to remaining single given their need for social support and cohesion in their already uncertain environment (Smith and Waitzman, 1994). Further, divorce or separation will tend to lower SES status.

Underlying much of the argument on the differences in life expectancy for the marriage variable is the archaic Darwinian notion that females will select the most desirable males for breeding, leaving the most undesirable males (i.e. those with poor genetic prospects) to remain single. While that may or may not have been true in earlier times, in the late 20th century an increasing number of individuals are making lifestyle choices that may include not marrying.

For this study, the census tracts were separated into quintiles based on their marriage index. If a census tract

had more than 1.7 married individuals to one single individual, it was placed in the most protected quintile, Q1. Correspondingly, if a census tract had 0.8 married persons to one single person it was placed in the least protective quintile, Q5. Males in Q1 lived to 77.41 years and those in Q5 lived to 72.38 years: a differential of 5.03 years. Females in Q1 lived to 81.59 years and those in Q5 lived to 80.48 years: a differential of 1.11 years (see table 23 and figure 24). The step-wise monotonic gradient was evident for both genders.

LIFE EXPECTANCY BY MARRIAGE RATES

Figure 24: Life Expectancy by Marriage Rates

Therefore, even though one may regard the theoretical underpinnings of this variable as archaic the results were very much as expected. They showed some differential for females and a significantly larger differential (larger than the normal gender differential) for males, to the extent that in the case of males marriage was the single

best social variable in demonstrating differences in life expectancy.

Percentage of Immigrants

This variable measures the percentage of landed immigrants per census tract. It is a well-established epidemiological fact that in Canada and many other industrialised nations landed immigrants at the individual level tend to live longer than others in their host countries. This is believed to be because most of these immigrants have to pass fairly rigorous physical examinations to gain entry to Canada, and because many of the most recent immigrants tend to come from higher socio-economic groupings in their home country as opposed to the lower socio-economic classes that tended to form the earlier waves of immigrants. This phenomenon has increased in recent years with immigrants coming from non-European countries and with the opening of the economic classifications of immigration. Further, it is believed that to immigrate requires a certain ambition and drive that in effect makes immigrants a self-selecting group and predisposes them to longer life expectancy.

Accordingly, all tracts with greater than 40% immigrants were placed in the most protective quintile, Q1, while those tracts with less than 16% landed immigrants were placed in the quintiles at most potential risk, Q5. A large body of literature on immigrant longevity and the

wide distribution of immigration between census tracts, this variable performed surprisingly poorly in showing differences in life expectancy. In fact, it demonstrated no significant differences at all (figure 25).

The life expectancies by quintiles were largely random and there was no clear pattern to any of the data. Why this variable should perform so poorly is a matter for speculation. It may be that Canada has such a large percentage

Figure 25: Life Expectancy by Immigration Levels

of landed immigrants from such diverse origins, ranging from refugee status to the older European wave of immigrants to the more recent wave of non-European immigrants, that the mere fact of being a landed immigrant bears no unique health related properties. Nevertheless, given that Q1 had an immigrant population of over 40%, that quintile alone (if the other literature is accurate) should

have borne some life expectancy advantage, if not an overall mortality gradient.

Although there is no clear gradient, the Q1 to Q5 differential does exist, being around two years for males and one year for females. The data seem to suggest that whilst there is no large advantage accorded to Q1, there is a significant drop off in Q5 with the other four quintiles being relatively equal. This suggests that instead of large immigrant populations being advantageous to life expectancy, it is rather that a large Canadian born population is more likely to be a detriment to life expectancy.

Aboriginals

The next socio-economic variable measures the percentage of aboriginals living in each census tract in Ontario. Tragically, short life expectancy for aboriginal populations throughout Canada is a well-documented phenomenon. This variable is included in the Alberta Health Study, and Jerrett considered it necessary to use it as a control variable so as not to skew the rest of his results (Jerrett et al., 1998). However, the Alberta Health and Jerrett studies included both rural and urban residents. Studying this variable at the ecological level in CMAs in Ontario was simply not possible, since, as with primary industry, there is not a large enough population dispersed throughout the province's CMAs to give credible

results. In fact numerically, the overwhelming majority of census tracts in Ontario when rounded up to two significant digits contained no aboriginal population. Like the primary industry variable, aboriginals in Ontario can only be studied if rural as well as urban areas are included or if the study is conducted at the individual level.

Mother Tongue

Francophones in general, and especially those living outside of Quebec, are seen to be disadvantaged in a number of ways in Canadian society, including education and income. This is in spite of official policies of bilingualism and preferential hiring treatment in such organisations as the federal civil service and Canadian Armed Forces. In common with the primary industry and aboriginals' variables, this variable did not perform well because of the small number of Francophones concentrated in a small number of census tracts in the province's CMAs, with a high concentration in a few tracts in Sudbury and Ottawa. Although a few census tracts contain a majority of Francophones, the vast majority of census tracts in Ontario contain few, if any, Francophones and certainly not enough in number to significantly demonstrate a life expectancy differential at the ecological level. As such, it is recommended that this variable only be pursued at the individual level or in cases where a select few census tracts with high Francophone populations can be studied

against their English-speaking neighbours. For example, intra-city studies in cities such as Moncton, Ottawa/Hull and Sudbury would be much more suitable for a study of this variable at the ecological level.

Religious Affiliation

It has long been theorised that individuals who participate in organised religion benefit from the social cohesion effects of being involved in such community organisations. Accordingly, those tracts with greater than 17% of individuals holding a religious affiliation were placed in the most protective quintile, Q1, while tracts containing less than 8% of the population claiming a religious affiliation were placed in Q5. Life expectancy for males in Q1 was found to be 74.71 years, and for those in Q5, 75.81 years: a difference of -1.10 years. The figures for females were 81.25 years in Q1, and in Q5, 81.35 years: a difference of -0.09 years (see figure 26). Given these small differentials it is perhaps best to conclude that this variable's gradient is relatively flat and was perhaps not best studied at the ecological level, or that this variable no longer plays a role in Canadian's SES.

Figure 26: Life Expectancy by Rates of Religious Affiliation

Percentage of Catholics

The Alberta Health study found high levels of Catholicism to be a detriment to life expectancy, although neither the theoretical basis, nor the literature source for using this variable is stated.

LIFE EXPECTANCY BY PERCENTAGE OF CATHOLICS			
	TOTALS	MALE	FEMALE
Q1	79.37	76.61	81.84
Q2	78.67	75.56	81.54
Q3	78.30	75.27	81.15
Q4	78.21	75.24	80.98
Q5	78.17	75.08	81.22
DIFFERENCE			
(Q1-Q5)	1.20	1.52	0.62

Table 24 : Life Expectancy by Percentage of Catholics

Accordingly, in this study, tracts with fewer than 24% of people claiming Catholicism as their religion were placed in the most protective quintile, Q1, while census tracts with

over 47% Catholic population were placed in the most at risk quintile, Q5. Life expectancy for males in Q1 was 76.61 years, while for those in Q5 it was 75.08 years: a difference of 1.52 years. The figures for females were 81.84 years in Q1 and 81.22 years in Q5: a difference of 0.62 years (see table 24 and figure 27).

While the gradients were relatively regular, the differences were again extremely small. Given the small differences in life expectancy and the rather weak theoretical underpinning it is difficult to see how this variable can be of much use at the ecological level studied here. Unless one is studying the question of organised religion and life expectancy explicitly, it is probably best to steer away from both these last two variables.

Figure 27: Life Expectancy by Level of Catholicism

Summary

Fourteen of the 24 variables studied performed well in the expected direction, if we use the arbitrary cut-off of 2.5 years as the combined gender differential. Three others performed as expected but in a slightly less pronounced fashion, while the performances of the remaining seven were either too erratic or too small to warrant inclusion in future studies. The economic variables showed the greatest robustness in displaying differences in life expectancy; the only exception was the participation variable, which showed a weaker but still pronounced differential. All the education variables studied performed quite well, although the differentials were not quite as large as for the income variables. The occupation variables performed poorly as a group, with only the quaternary sector workers still showing the expected gradient at a reasonable strength. Housing variables performed as expected, with the repair variable strongest among them. The social variable results were as mixed as the make-up of the variables themselves. Those surrounding lone or single parenting showed a high degree of mortality differential, and marriage performed surprisingly strongly in the case of males. However the religious, linguistic and aboriginal-based variables performed very poorly.

In short, if one was forced to pick one variable to display SES life expectancies in Ontario, one could safely choose between the 10 or 15 variables shown to perform well

here. In effect, this is what Wilkins did by choosing his low-income cut-off, the first variable tested here. Given the strong theoretical foundation behind the LICO variable it may well be not just the best for showing differences in life expectancy, but also the easiest to defend in terms of theoretical abstractions.

CHAPTER 5

SELECTED SUB-POPULATION ANALYSIS

Infant Mortality

In the past infant mortality has been used as a surrogate indicator of a population's health as a whole. It is still used in this way, albeit to a lesser degree. It is a tautology to state that high infant mortality rates have a significant impact on the overall life expectancy of a population. However, towards the end of the 20th century infant mortality has become an increasingly rare event. Because of this decrease, it may now have lost some of its predictive strength in terms of a population's health in general.

As far back as *The Black Report* SES differentials in infant mortality appeared to be narrowing. However, *The Black Report* excluded all out-of-wedlock births and for that reason many believe that the narrowing uncovered was highly suspect. Critics believe that while overall infant mortality is dropping, SES differentials remain constant or perhaps are increasing (Davey-Smith et al., 1990). Others

have tied the economic insecurity argument, discussed earlier in the unemployment and participation index sections, directly with infant mortality (Catalano, 1991).

In the Wilkins study previously cited (Wilkins et al., 1991) he found overall infant mortality and socio-economic differential decreasing in Canada. However, while the SES differential for infant mortality had been greatly reduced, it still existed in 1991. Wilkins found that overall infant mortality rates had been cut in half in Canada between 1971 and 1986. The rate of death in Q5 in 1971 was approximately 20:1000 with the rate in Q1 being approximately 10:1000. The rate in 1986 for the most at risk quintile had dropped to 10:1000, equal to the least at risk quintile of 15 years earlier and suggesting a 15 year lag in socio-economic equality in infant mortality. In Wilkins' 1991 data he found another drop in overall infant mortality, although the rate of decrease had slowed dramatically. This corresponds to our earlier "increasingly rare event argument", and gives rise to one possible conclusion that infant mortality in developed worlds may be reaching some kind of natural floor (Wilkins et al., 1991).

The chart (see figure 28) also shows the corresponding data from this study, keeping in mind that this is for Ontario while Wilkins' findings are Canada-wide. The findings for Ontario in 1991 are very similar to the Canada-wide findings for the same year, the major

differences being that Ontario had a slightly lower rate of overall infant mortality while the Q1:Q5 differential was slightly above the national average. Given the relative rarity of this event, the Ontario and Canada-wide findings are not significantly different.

Figure 28: Infant Mortality Rates

Infant mortality Q5/Q1 ratios were calculated for all the variables in the preceding section in the same manner as life expectancy. The results in many cases were the same, with many of the best performing variables showing some significant differential between Q1 and Q5. Notable differences were very variable, where those differentials were not found in the life expectancy analysis (see figure 29). Also of special interest is the variable "percentage of infants born to single mothers" a group of children known to be at risk at the individual level.

Figure 29: Q5/Q1 Infant Mortality Ratio

high infant mortality differentials found in the tenure. Again, we find a large SES infant mortality differential in this variable, especially for male children.

Rather than pursue all these variables again, replicating the results found in the life expectancy variable, we turned our attention to the following questions: "How much does this infant mortality differential contribute to the overall life expectancy differential for a few select variables?" and "Can differences in SES life expectancies largely be accounted for by differences in infant mortality or are these socio-

economic differentials found throughout an individual's life?"

To answer these questions we analyzed life expectancy from birth (done in the previous section) and life expectancy for those individuals who survived past the age of one. This removes all bias of infant mortality in the first year of life. A third calculation for all individuals over the age of 25 was performed to remove the bias of all childhood, adolescent, and early adult increased death rates that may be attributed to socio-economic variables. This allowed a test of a further thesis that if socio-economic mortality differentials are not explained in the first year of life they are largely caused early in life (i.e. in the first 25 years).

**Q1-Q5 Differential Life Expectancy From Selected Ages
For Selected Variables**

Figure 30: Q1-Q5 Differential Life Expectancy from Selected Ages for Selected Variables

Because we are dealing with differentials and not absolute life expectancy one would expect that if the phenomenon of socio-economic differences in life expectancy

persisted throughout life the differential would be largely the same at different times in an individual's life cycle. As the charts show, this is what happens (see figure 30).

For the LICO variable the differential at birth is about three years for both sexes, while when infants and youths are removed the difference is slightly less. The same holds true for the other two variables tested. The rent index was included because of its high socio-economic differential shown for infants and the lone parent variable was included because of its strong theoretical underpinning.

Figure 31: Q1-Q5 Differential Life Expectancy (as percentage) Selected Variables

This current evidence does not support the view that much of SES mortality differential can be attributed to those differences in infants and youths. The next chart (see figure 31) shows the percentage of difference in SES life expectancy that can be explained by differences in SES

infant mortality: a clear 88-93% of differential life expectancy cannot be explained this way. Therefore, while it is true that infant mortality does contribute slightly disproportionately to overall SES mortality differentials, any claim that it is a major contributing factor is clearly repudiated. The results when the deaths of all those under the age of 25 are removed show largely the same pattern.

The results shown here demonstrate that even if one could theoretically eradicate all SES differentials in infant mortality, this would address only around 10% of the phenomenon, and between 88-93% of SES differences in life expectancy would persist. This is not to suggest that many factors influencing ultimate life expectancy do not have their beginnings in infancy and early childhood.

The Elderly

Several authors, including Wilkins in his Canadian study, determined that SES mortality diminished markedly after the age of 74 (Wilkins et al., 1991). However, evidence to the contrary was found at the individual level in a 10-year follow-up to *The Black Report*. This found a mortality differential, when measured by PYLL, for the first time in individuals of retirement age (Davey-Smith et al., 1990). Another British longitudinal study concluded that there was some shrinking of the gradient but that it persisted until the very end of life (Fox et al., 1985).

For studies done at the ecological level it is relatively easy to make the case (especially for the elderly) that ill-health might cause an individual's SES to drift sufficiently downward late in life to place them in a poorer socio-economic status than they experienced earlier in life. Of course, how far an individual elderly person's SES would drop would largely depend on the social safety net of the society in which they lived and the amount of wealth they had accumulated in times of better health and SES status (Fox et al., 1985).

To ascertain whether, in the current data set, differences in life expectancy persist into later life, we selected the same three variables that were used in the study of infant mortality. For each variable a ratio was created whereby the Q5 life expectancy at birth was divided by the Q1 life expectancy, giving us the percentage of life expectancy someone in Q5 would have vis-à-vis someone in Q1. For example, using the LICO SES variable it was discovered that someone in Q5 could expect at birth to live 96.17% as long as someone in Q1. For the rent variable, those in Q5 could expect at birth to live 97.42% as long as those in Q1 and for the lone parent variable those in Q5 could expect 96.32% of the life expectancy at birth of their Q1 counterparts.

By checking this ratio at age 75, one of three possible outcomes was possible. The Q5 to Q1 ratio could remain virtually the same, suggesting that mortality

differential persisted throughout life. The Q5 to Q1 ratio could approach 100%, suggesting that these age groups now had equal life expectancies; in that case we could conclude that socio-economic mortality differentials had dissipated by age 75. Finally, it might be that those in Q5 now had a longer life expectancy than those in Q1, suggesting a reversal of the earlier trend.

The findings of the analysis on these three variables were somewhat mixed (see figure 32).

Figure 32: Life Expectancy, Q5/Q1 Ratio Selected Variables for the Elderly

For the low-income variable the Q1/Q5 percentage for an individual at age 75 was 98.16%, meaning that approximately half the mortality disadvantage demonstrated at birth had disappeared by age 75. This variable supports the hypothesis that mortality differentials are significantly decreased but do persist throughout life. However, the

findings for both the lone parent variable and the rent index variable were markedly different, with both showing a dramatic reversal in the mortality differential pattern. For the lone parent variable, those in Q5 were found to be living slightly longer than those in Q1; while in the rent index those in Q5 and over the age of 75 were living markedly longer than their Q1 counterparts. In fact, they lived much longer in percentage terms than any of the at birth life expectancies for Q1 under any of the variables studied here. In the case of the rent variable, the index went to 105.80, meaning that a person of low SES as measured by the rent variable could expect to live five percent longer than their higher SES counterpart from age 75 onward.

Because these results were somewhat surprising, a cursory review was made of several other variables included in the original study as to their effect on differences in life expectancy in the elderly. Most performed in much the same way as the LICO variables did, showing a reduction but not an outright reversal in mortality differential in the elderly. Others, such as participation in the workforce, showed the pattern of outright reversal displayed by the lone parent and rent variable. In general, these findings were much more inconsistent than those for life expectancy at birth. This may be in part because there are not many years of life left after the age of 75. Therefore, we are

dealing with a smaller number of years on which to base our percentages, leading to findings that are more volatile.

Because the mortality gradient reversed itself in several variables, it was thought useful, as a final step in analysing this situation, to determine the age at which the mortality differential reappeared in its normal fashion. In the case of lone parents, the reversal at age 75 and over was relatively small and quickly reversed when the analysis was performed at age 70. For the rent index, where there was a relatively large reversal of mortality ratio, this persisted at a somewhat smaller level at age 70 and it was not until age 65 that the normal gradient, however small, (suggesting SES equality) returned to those individuals over the age of 65.

The safest conclusion may be that some, and perhaps all, of the SES mortality differential dissipates late in life but that the variable must be chosen with much care, otherwise some unexpected and perhaps artefactual results could occur. It may be that the choice of variable when studying life expectancy and mortality differentials in the elderly may require different theoretical constructs over and above those normally associated with socio-economic mortality and life expectancy at birth.

Sex Differentials

As became evident during the analysis of the individual variables, there are significant differences in

the magnitude of differentials between male and female SES life expectancies. In most industrial societies, women have a longer life expectancy than their male counterparts do. This is thought to come about for two reasons, one biological (noted in most species in nature) and one behavioural, where the gender roles imposed by society place men at different social, occupational and behavioural risks. The main disagreement about this gender difference in life expectancy surrounds the relative importance of these two factors (Millar 1983).

In 1971, using data similar to that in the current study, Millar studied the differences between male and

LIFE EXPECTANCY AT BIRTH BY SEX AND INCOME LEVEL URBAN CANADA, 1971						
	INCOME LEVEL					TOTAL
	(HIGH) 1	2	3	4	(LOW) 5	
MALES	72.47	71.14	70.05	69.24	66.33	69.95
FEMALES	77.45	77.00	76.60	75.63	74.62	76.36
ABSOLUTE SEX DIFFERENCE F-M	4.98	5.86	6.55	6.39	8.29	6.41
SEX RATIO F÷M	1.07	1.08	1.09	1.09	1.12	1.09
<p>The sex ratio is conventionally expressed as the male rate divided by the female rate. In this instance, the ratio is expressed as the female life expectancy at birth divided by male life expectancy at birth. Similarly, the sex difference is the female life expectancy minus the male life expectancy.</p> <p>SOURCE: MILLAR, 1983.</p>						

Table 25: Life Expectancy at Birth by Sex and Income Level, Urban Canada, 1971

female life expectancies based on quintiles ranked by census tracts' median income. He found gender differences at all income levels in all age groups with discrepancies growing markedly larger in the low-income groups (See table 25).

With reference to Q1 the difference between male and female life expectancy was 4.98 years while the gender difference for Q5 in 1971 was 8.29 years.

Life Expectancy at Birth by Sex and Income Level Urban Ontario 1991					
	Q1	Q2	Q3	Q4	Q5
Males	78.59	76.91	75.74	74.55	72.29
Females	82.14	81.59	81.33	81.34	80.25
Diff	3.55	4.68	5.59	6.79	7.96
Ratio	1.05	1.06	1.07	1.09	1.11

Table 26: Life Expectancy at Birth by Gender and Income Level Urban Ontario 1991

It is possible to compare Miller's 1971 data for the entire country with our current 1991 data for the province of Ontario (see table 26). We find the male/female difference in Q1 is 3.55 and in Q5 7.96, showing a small decrease from the 1971 figures. Nevertheless, the significant difference between the sexes and the significantly larger differential in Q5 persists. Why these life expectancy differentials should occur is somewhat unclear, but what is clear is that females, in the name of gender equality, have taken on many more traditional male behaviours in the intervening 20 years

such as their position in the paid labour force.

Perhaps even more surprising and more salient to the present analysis is the continued and persistent robustness of the gradient between males and females when analyzed across a wide spectrum of socio-economic variables, as was done earlier in this paper. The vast majority of variables

tested here showed a gradient between Q1 and Q5 males of from three to six years (see figure 33-legend on page 123). The differentials for females were consistently smaller than for males, and in a narrower band between 1.5 and 2 years (see figure 34). Thus, the Q1:Q5 differential was often double and sometimes as much as four times larger between males and females, with the median income variable showing the largest discrepancy between male and female gradients of 4.4 years between the genders (see figure 35).

Figure 33: Q1-Q5 Life Expectancy Differential - Males

This variable, coincidentally, was the one that Millar chose to study in his 1971 work.

Very few studies have addressed directly the question of why this gradient should be so different between males and females. However a 1991 paper tried to find the answer by focusing on three main areas: whether the choice of variable could affect the differential; whether there was a confounding variable influencing these mortality differentials; and whether differences the cause of death structure between the genders might partially explain the differences in life expectancy differentials (Koskinen and Martelin, 1994).

Figure 34: Q1-Q5 Life Expectancy Differential - Females

This type of study requires extremely precise data, the kind not often found in Canada. In Koskinen's study, the data was from Finland, based on census data linked to individual death records from 1981 through 1985. The authors tested a variety of SES indicators including education, occupation, and housing conditions and discovered much as we have in the current study that the gradient persisted regardless of the socio-economic measure used (Koskinen and Martelin, 1994).

GENDER GAP (MALE DIFFERENTIAL - FEMALE DIFFERENTIAL)

Income

1. Lico (Wilkins)
2. Lico
3. Median Income
4. Unemployment rate
5. Workforce Participation
6. Government transfers

Education

1. Less Than High School
2. More Than High School
3. University Graduates

Occupation

1. Quaternary
2. Manufacturing
3. Primary Sector

Housing

1. Tenure
2. Overcrowding
3. Major Repairs

Social

1. Single Births
2. Lone parent Families
3. Number Of Children at Home
4. Marriage
5. Immigrants
6. Aboriginals
7. Francophones
8. No Religious Affiliation
9. Catholicism

Figure 35: Gender Gap (Male Differential – Female Differential)

With the choice of dependent variable ruled out, the authors then focused their attention on their second

objective, confounding variables. Using educational status as their dependent variable, they isolated marital status as a potential confounding variable. They found that 11% of men in the highest educated class remained single whereas the corresponding number for females was 32%. However, at the lower end of SES, as measured in education, they found no difference in the rates of marriage between the genders. Building theoretically on the work discussed earlier - marriage acting as protectant to life expectancy in general - they postulated that women of high educational status did not benefit fully from their educational attainment because they did not have the additional protective characteristic of marriage at the same rate as their male counterparts. This had the net effect of lowering the protective influence that the women's education should have bequeathed to them, thus flattening the female gradient. Using an index of dissimilarity to measure differences between males and females, they found that this one factor alone changed the index of dissimilarity from 64% before the confounding variable was taken into account, to around 90% after the marriage rate was controlled for.

The final question asked by the Finnish authors was "Can differences in the cause of death structure between males and females be implicated in the differences in life expectancy gradients?" They found, as others have, that men are disproportionately affected by causes of death that

usually affect members of lower SES, such as accidents, violence, suicide, and alcohol poisoning. Because these causes of death occur more often in males, members of low SES, and disproportionately to the young, they have the effect of sharply steepening the male SES life expectancy differential. In contrast, consider the case of breast cancer, the cause of death for 9% of women in the Finnish study. Breast cancer is still one of the few diseases that demonstrates a reverse mortality gradient. Having such a significant percentage of women die of a disease that displays a reverse mortality gradient has the effect of flattening the overall female SES mortality gradient.

To test the effects of death structure on mortality differential, the authors created a hypothetical situation where they retained the overall rate of female mortality but had the female cause of death structure replicate the male cause of death distribution. When this analysis was applied, the authors found that the vast majority of mortality differential gradients between males and females disappeared.

In comparing the Finnish study with the current study, only the choice of variable and its effect on mortality differential could be directly compared. Our findings were largely similar to theirs (over a much wider range of variables), that is, the choice of variable made little or no difference in most cases in explaining the size of the gender differences in life expectancy gradient.

Replicating these studies in Canada would be extremely difficult given that they are better done at the individual level with linked records that do not exist in the Canadian context.

Nevertheless, although full replication of their results was not possible, data obtained from the 1991 Ontario Health Survey made it possible to check one of the major underpinnings of their thesis that the rate of marriage acts as a confounding variable on the life expectancy of educated women. An initial look at the data suggests that the situation that existed in Finland, of low marriage rates among highly educated females, is not present in Ontario. For example, if we define the most educated segment of our population as those with at least some post-secondary education we find that single, never married females make up 19.4% of this group, while the figure for males is 20.2%. That is, the figures are virtually the same, a sharp contrast with the 300% increase in single females over males found in the Finnish study. Without this significant difference in marriage rates the theoretical basis for marriage as a major confounder in gender mortality differentials cannot be substantiated in an Ontario context. While the Finnish work is important it appears their results on confounding variables cannot be applied universally.

The work on cause of death structure, however, does ring true for many other jurisdictions, including Ontario, and deserves replication, data permitting.

CHAPTER 6

MULTIPLE REGRESSION MODEL

Socio-economic status is a multidimensional phenomenon such that in combining different socio-economic variables, it may be possible to greatly enhance the explanatory power of any one individual variable. While usually the goal in such cases is to attain the highest R^2 value so one can claim that a given percentage of the variation in the phenomenon under study can be explained by a specific combination of variables, our goal here is considerably more modest.

The purpose of the model building in this case is to answer the geographic question, "Does place make a difference?" Up to this point in the study, we have been working with neighbourhoods inside the 10 CMAs in Ontario, sorted along one socio-economic dimension or another with no regard to keeping them separate as the cities (CMAs) themselves. Now the focus will shift slightly from the aggregate neighbourhoods contained in the CMAs to the CMAs themselves.

The fundamental question to be posed in this section is "Is the socio-economic profile of a community sufficient to explain the life expectancy of the population in that

community?" If this is indeed the case then it could be provisionally concluded that place does not make a difference in life expectancy. Conversely, if socio-economic profile, as defined by the regression model, cannot explain life expectancy in these communities we can then conclude that in some or all cases either the model is deficient, or place may indeed make a contribution to life expectancy over and above SES status. Therefore, the construction of this model does not imply that a certain combination of socio-economic variables can explain a given portion of life expectancy. Rather it is an attempt to build the best socio-economic footprint for the communities in general, at which point the communities can be layered into the model as dummy variables to answer our initial question "Does place matter?"

Hamnett argues that space is not unimportant, but that there is a strong relationship between space and social structure and it is simply not possible to understand one without reference to the other. Simply put, social process becomes spatial process and it is difficult to tease out which element exactly is being studied. As a result, phenomena that often manifest themselves spatially are largely results of social processes and therefore spatial analyses often conceal or mislead as much as they can uncover. This leads to what Hamnett calls the "fetishism of space" where relationships between social groups and classes are presented as relationships between areas.

Using space as an independent determining influence, in Hamnett's view, may distract geographers away from the wider socio-economic context (Hamnett, 1979). It is hoped that the construction of this paper responds to most of these criticisms through addressing both SES and ultimately adding place as an additional (dummy) variable. Working at the ecological level the overwhelming majority of this paper has dealt with the socio-economic dimension and it is only now after a thorough socio-economic analysis that we are adding a spatial dimension.

CORRELATION BETWEEN SELECTED SOCIOECONOMIC VARIABLES AND LIFE EXPECTANCY AT BIRTH (ALBERTA, 1991)										
	ABR	CATH	IMM	INC	EDUC	UNEMP	WED	TEENF	CHLD	SNGLP
LIFE EXPECTANCY AT BIRTH	-0.90	-0.60	0.52	0.25	0.68	-0.81	-0.92	-0.94	-0.72	-0.49
ABR		0.60	-0.44	-0.18	-0.70	0.88	0.90	0.96	0.88	0.49
CATH			-0.20	0.19	-0.35	0.62	0.69	0.53	0.53	0.46
IMM				0.29	0.76	-0.07	-0.38	-0.44	-0.49	0.42
INC					0.55	-0.02	-0.04	-0.28	-0.12	0.01
EDUC						-0.43	-0.51	-0.69	-0.80	0.07
UNEMP							0.86	0.88	0.74	0.77
WED								0.94	0.71	0.59
TEENF									0.81	0.53
CHLD										0.20

Table 27: Correlation between Selected Socioeconomic Variables and Life Expectancy at Birth

In the Alberta Health study, done at the public health unit level, instead of using the independent variables the authors decided to group their variables into two indices, one representing social/cultural discord and the other showing economic advantage. The authors claim this to be the most effective way to deal with the problem of a small

number of cases (n=17). Moreover, many of their variables, as tends to be the case in this type of analysis, were highly inter-correlated (see table 27), and they therefore viewed it as reasonable to group these variables into indices. They found that the social cultural discord index had a greater negative effect on life expectancy than the economic advantage index had positive effects (Health Surveillance 1998a) (see figure 5).

Others have argued that a simple combining of factors is often inappropriate, especially when inter-correlation is a problem (Fieldhouse and Tye, 1998). They argue this is a job for multiple regression models which can control for several variables simultaneously, making crude indices obsolete as they often obscure important associations (Liberatos et al., 1998). The problem of artificially high R^2 values can be significantly reduced by using a large number of cases, as has been done with our over 1500 census tracts.

A regression approach was used for this model for the following reasons: we could reduce multi-correlation by our large number of cases; the large number of variables meant that any variable highly inter-correlated with others in the model could be substituted for another similar variable; and the introduction of cities as dummy variables was by far the most direct way to answer our questions about which cities' health outcomes were not predicted well by their SES profile, in effect, giving them significant

unique city characteristics over and above the city socio-economic profile.

Duncan, Jones and Moon state that to establish a causal relationship you must exclude at least three possibilities: chance; confounding by unknown variables; and confounding by known covariates. They believe this is best done by a multilevel approach - the individual level being level one and area or ecological level being level two. The lack of individual level data meant that this approach was not available for this study. (Duncan et al., 1993).

However Duncan et al. caution that any spatial findings must be tempered with the knowledge that a better model could have ruled out any spatial relationships. In their multilevel analysis of health-related behaviour in the regions of Britain, they concluded that location did not contribute significantly to health outcomes. When they studied such health-related behaviour as smoking and diet, they found not so many regional differences in behaviour as socio-economic differences between the regions. Thus, they concluded that although regional differences were found in health-related behaviours such as smoking, drinking, etc., most of this could be explained by the socio-economic composition of those regions (Duncan et al., 1993).

To reiterate briefly what was covered in the data and method section, the object was to determine whether a life

expectancy in a city (see figure 36) could be explained by its socio-economic profile.

LIFE EXPEECTANCY BY CITY

Figure 36: Life Expectancy by City

However, this initial attempt had to be abandoned because the number of cities ($n=10$) was not sufficiently large to produce a meaningful multiple regression model. In fact, using the single variable "repair status of homes" one could build a model sufficiently strong that it could not be improved upon by the addition of any of the other 23 variables in the study. In order to continue the model building process the statistic "years of life lost potential years of life" (YLL/PYL) had to be substituted for life expectancy. As demonstrated earlier, these two health measures were closely related (see figure 37).

Again, this substitution was made because life expectancy cannot be calculated for small geographic units such as neighbourhoods, whereas the secondary statistic YLL/PYLL can be generated for each individual

neighbourhood. These neighbourhood scores can be summed to give the city as a whole a meaningful YLL/PYLL profile while retaining all 1500+ data points. Even with this new statistic and all the data points, many methodological considerations still had to be overcome.

Scatterplot of the CMA's Life

Expectancies and YLL/PYL

Figure 37: Scatterplot of the CMA's Life Expectancies and YLL/PYL

Several steps had to be taken in preparing the data to make it useable in this type of model. This was made necessary by a combination of multi-collinearity between many of the independent variables, and another basic violation, the assumption of common variance in building multiple regression models. The first consideration was to

transform the YLL/PYL statistic by taking its square root (the transformed YLL/PYL variable was renamed rooty).

Histogram

Dependent Variable: YLL/PYL

Figure 38: Histogram – Dependent Variable: YLL/PYL

It was hoped that in so doing the distribution of the statistic would then be closer to normal (See figure 38 for untransformed distribution and Figure 39 for transformed), another assumption for the data used in building a multiple regression model.

Figure 39: Histogram – Dependent Variable: ROOTY

Figures 40 and 41 demonstrate another disturbing trend whereby the expected cumulative probability exceeded the observed cumulative probability at the low end of the distribution, while the observed cumulative probability exceeded expected cumulative probability at the high end of the distribution (See figure 37 and 38 for before and after transformation). The data displayed not only non-normality but also a pattern of deviation. After the transformation the situation was improved considerably but one additional step was required. To achieve normality 23 of the tracts in the study (1.5%) were removed as being outliers. While the removal of data to “make it fit” is always problematic

it was felt that because death at the neighbourhood level is a somewhat rare event the chance of deviant or exceptional results was quite high.

Figure 40: Normal P-P Plot of Regression Standardized Residual Dependent Variable: YLL/PYL

Because of its relative rarity, it was deemed that some tracts could easily have too many or too few deaths to fit any reasonable model. For example, too small a YLL/PYL statistic could be generated where no one in a particular census tract died that year. In some tracts with either high socio-economic status or low populations, this may have been an acceptable number. However in many larger or lower socio-economic tracts this finding would have caused the tract to become an outlier in an otherwise sound model. Too many deaths, or in this case potential life years lost, could be created by a number of situations not likely to

repeat themselves in other years. In some of the smaller tracts as few as two infant deaths could have caused this tract to become an outlier with too many potential years of life lost. To give another example, take the tragic occurrence of a fatal automobile accident where the car contains three or four teenagers all living in the same census tract.

Figure 41: Normal P-P Plot of Registration Standardized Residual Dependent Variable: ROOTY

Again, this would have caused too many potential years of life lost, causing that particular neighbourhood to be an outlier given the model constructed. It was felt reasonable, given these circumstances and many others like them, to remove 1.5% of the census tracts in the study to

meet the assumptions required for regression model building.

The first step in the modeling process was to build a zero order correlation matrix to determine two things: how the independent variables were inter-correlated with each other, and which variables correlated highly with the YLL/PYLL statistic (see appendix b). Model building of this type is a highly iterative process where one slowly inserts variables in different combinations to see the effect they have on the overall model and simultaneously the other variables already included in that model. It should be noted here that due to multi-collinearity not all variables were readily available for insertion into the model. Some, because of their highly inter-correlated nature with a large number of other variables, would have been excluded by their inclusion a large number of other variables.

COEFFICIENTS ^a							
MODEL	UNSTANDARDIZED COEFFICIENTS		STANDARDIZED COEFFICIENTS	T	SIG.	COLLINEARITY STATISTICS	
	B	STD. ERROR	BETA			TOLERANCE	VIF
1 (CONSTANT)	20.842	.668		31.208	.000		
PART_PER	-8.59E-02	.010	-.240	-8.837	.000	.556	1.79
REPAIRS	6.999	1.921	.089	3.643	.000	.694	1.44
LONE_PAR	7.532	1.226	.146	6.144	.000	.732	1.36
kds@hmc	-3.762	.318	-.314	-11.829	.000	.585	1.71
UGRADES	-2.186	.703	-.072	-3.109	.002	.771	1.29
D_SUD	1.104	.423	.054	2.611	.009	.971	1.03
D_KITCH	-.917	.299	-.063	-3.067	.002	.984	1.01

a. DEPENDENT VARIABLE: ROOTY

Table 28: Coefficients^a

However, throughout the process several variables continued to perform extremely well without suffering from problems of multi-collinearity. Two that stand out were home repairs and the number of children at home. After a number of variables were selected and R^2 was as large as could be attained a few other statistics were consulted to make sure that the multi-collinearity assumptions had not been violated.

First, the variance inflation factor exerted on the model by different variables was checked; it was considered satisfactory if at all times these levels were kept under two (see table 28, far right column). Second, we looked at the discrepancy or difference between R^2 and adjusted R^2 . It was felt that as long as these were relatively close there was not much linear association and associated collinearity between the independent variables. Once the socio-economic variables had been entered into the model, an adjusted R^2 of 0.376 (see table 29) was attained.

Model Summary ^b				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.616 ^a	.379	.376	2.5031
a. Predictors: (Constant), D_KITCH, REPAIRS, D_SUD, UGRADS, KIDS@HME, LONE_PAR, PART_PER				
b. Dependent Variable: ROOTY				

Table 29: Model Summary^b

However, as stated at the beginning of this section the size of the R^2 was not the ultimate goal of this model. Rather, our goal was to insert the 10 individual communities as dummy variables into this already constructed SES model to see whether any of them contributed significantly to the explanatory power of the overall model. If they did this would indicate that the socio-economic variables alone did not explain their YLL/PYLL given their SES profile as defined by the model.

YLL/PYL

CITY	N	MEAN
OTTAWA	153	140
OSHAWA	49	133
TORONTO	789	132
HAMILTON	159	158
ST. CATHARINES	82	164
KITCHENER	75	115
LONDON	86	148
WINDSOR	58	169
SUDBURY	37	192
THUNDER BAY	30	161
TOTAL	1518	140

Table 30: Mean YLL/PYL by Ontario C.M.A.

Taking a step back to life expectancy for a moment, life expectancy by community was calculated (see figure 46). These results show that Kitchener had the highest life expectancy and was were followed closely by Toronto and Ottawa. At the low end of the spectrum, Sudbury had by far the lowest life expectancy, followed by Windsor and Thunder Bay. When the health indicator was switched from life expectancies to YLL/PYLL, much the same pattern

emerged. Kitchener had the lowest number of potential life years lost at 116 per 100,000 years of life lived, whilst Sudbury had the highest rate per 100,000, at 192 (see table 30). The positioning of all cities in the study remained largely, although not exactly, the same. The question remaining then is whether or not a city's YLL/PYL, which, as we have seen closely corresponds with life expectancy (see figure 37), can be predicted within statistical significance by its SES as defined by the model constructed here. In other words, is Kitchener's health outcome explainable by its high SES and is Sudbury's poor health outcome a result of its lower SES vis-à-vis the other cities in Ontario, or are there specific spatial factors over and above the SES profile constructed here potentially at work?

The findings for the cities at the extremities of the YLL/PYL indicator, Kitchener at the high end and Sudbury at the low end, were that health outcomes could not be explained fully by SES as defined by this model (see table 28 column 1 and 4).

In conclusion, the results of space as opposed to socio-economic influence on health outcome appear to be somewhat mixed. While eight out of ten cities that formed the mid-range of health outcomes can be explained by the socio-economic model created, those at the high and low ends cannot be explained by their SES. The reasons for this cannot be determined in this current study, but the

likely next step would be to analyse the individual level behaviour in these communities to see whether that could help explain why their health outcomes were better or worse than their SES would have predicted. Because the cities that did not match the model were found at the extremities it may be that there is some sort of multiple or compounding effect in places where those with significantly higher SES not only benefit from that SES but get an extra boost from this high status. Conversely, at the low end those suffering from particularly low SES are doubly affected because of that low status. Alternatively, it may be that the low SES is accompanied by higher than expected rates of behaviours such as smoking, drinking and other known correlates to poor health, while the reverse may be true in Kitchener.

For example, if one found extremely low smoking or drinking rates in Kitchener, even lower than would have been expected by its SES, this could lead one to conclude that the combination of ecological SES plus abnormally low rates in detrimental individual behaviour could have contributed to its higher than expected health outcome. If those individual level behaviours were unique to place, in this case Kitchener, one could conclude that place played a role in determining these behaviours, as others of like SES status do not exhibit them.

Overall, if one had to make a determination based on these data of whether place made a difference to health

outcomes in Ontario in 1991, over and above the effect of a community's SES, it would be extremely difficult to conclude that it did. One gets the overwhelming feeling that if a better model could be specified then one could quite easily expand from the eight cities already captured under the model to have no place effect, to perhaps the two that did show some place effect. Extra evidence for this is derived from the city variables made smaller contributions to the model than any of the SES variable included (see table 28 column 4).

CHAPTER 7 EXPLANATIONS OF DIFFERENTIAL MORTALITY BY SOCIO-ECONOMIC STATUS

The results of early studies on SES mortality differential were surprising to many who believed that universal health care, or an enlarged welfare state, had largely ameliorated this problem in the industrialised world during the second half of this century. Because of studies such as *The Black Report* and the work of Kitagawa and Hauser, methodologies came under increasing scrutiny and criticism. As late as the mid-80s some believed that their findings were artefactual in nature and could be explained by methodological shortcomings. Two sources of potential artefactual error were commonly cited: the numerator/denominator bias discussed earlier, and the occupational classification, where the size of the SES

occupational grouping had changed dramatically over the decades.

When additional studies were completed, especially longitudinal studies such as Whitehall, and the Fox et al. study, these clearly demonstrated that even if numerator/denominator bias did exist in the earlier studies it did not significantly affect the overall findings. Longitudinal studies follow the same individuals throughout a portion of their lives, with no possibility of placing different individuals into a numerator but not a denominator. With the passage of time, the increasing number of studies that have been done cross-sectionally, longitudinally, ecologically, and at the individual level have demonstrated that while many of the initial criticisms of the early methodologies were sound, they in no way invalidated the general thrust of their findings. That is to say, socio-economic mortality differentials are a real phenomenon, not an artificial construct of methodological problems in the studies that find them (Liberatos et al., 1988).

The Black Report identified four possible explanations for SES differences in mortality. Of these, artifacts have since been discounted, while health selection or reverse causation has been discussed in various sections of this paper. The third and fourth possible explanations were cultural\behavioral differences and a

structural\materialist explanation (Davey-Smith et al., 1990).

The underlying theoretical assumption of most research into this phenomenon is that low SES causes poor health outcomes. Reverse causation postulates that the reverse may actually be true where an individual's poor health status forces them to drift slowly to a lower SES status than they would have otherwise attained. When viewed cross-sectionally it is not possible to determine the direction of causation.

The pre-eminent example of reverse causation in the literature is an ecological level study of schizophrenics and their SES (Giggs, 1996). The case of schizophrenia is especially relevant here because the choice of socioeconomic variable proved to be pivotal in uncovering the reverse causality. Initially it was believed that SES and schizophrenia were related. Data suggested that lower SES individuals were at high risk of developing schizophrenia, thus implicating SES etiologically in the onset of schizophrenia. A contrary view held that the lower SES of schizophrenics was due to the debilitating nature of their disease, and that their current SES was lower than that held by their parents and themselves in childhood. In the initial studies of the phenomenon, researchers used an index heavily based on education and found no downward mobility or credence to the reverse causality argument, thereby supporting the analysis that SES was somehow

implicated in the onset of schizophrenia. However, the choice of the education variable turned out to be misleading as education is normally completed by late adolescence, whereas schizophrenia usually has its first manifestations in early adulthood, after the completion of education. Therefore, by selecting education as the main SES variable the authors had unintentionally biased the results of their findings.

Later studies used occupation as their SES variable and consistently found downward drifts in the SES of schizophrenics after the onset of their disease. This supported the hypothesis that low SES was not implicated in schizophrenia, but rather that schizophrenics were unable to maintain the SES that they had held before the onset of their disease. The lesson learned here is that one must carefully bear in mind the indicator used, especially vis-à-vis the stage of life at which the disease being studied manifests itself (Liberatos et al. 1988). However, it is the uniqueness of schizophrenia that makes it so well known in the literature.

Most longitudinal studies conducted on SES mortality differentials substantiate the claim that social causation not social selection (reverse causation) is the true direction of the phenomenon. Longitudinal studies consistently find that low SES status throughout life is the underlying cause of the differences in life expectancy. It is also argued that macro level effects cannot be caused

by reverse causation. For example, an individual's unemployment status can be influenced by his/her poor health but it is extremely unlikely that the high unemployment of a particular community or place is caused by the poor health of that community. Yet, we have consistently seen through unemployment and other economic insecurity arguments how communities that are affected by this type of phenomenon do suffer from lower life expectancies (Davey-Smith et al., 1990). Even if one rules out artifacts and reverse causation, some of the thorniest explanatory problems of SES mortality differential remain.

Excluding artifacts and reverse causation, those explaining SES mortality differential fall into two basic camps - those who subscribe to cultural/behavioural explanations and those who believe in the materialist/structural explanations. It would be incorrect to characterise this as an either/or debate, rather it is about the relative role that each of these play in the overall SES mortality differential picture. This debate again stretches all the way back to both Kitagawa and Hauser and *The Black Report*, with the latter arguing that while cultural/behavioural factors did have some explanatory relevance, more of the evidence pointed towards a materialist/ structuralist explanation (Feinstein 1993). Kitagawa and Hauser came down on the other side of the argument, citing education as their single most reliable SES variable in showing mortality differences. They argued

that in the United States at least the prominence of the educational variable argued for modification of the behavioural aspect of individuals. They believed that much of the ill health and mortality differentials between Americans could be explained by smoking, sedentariness and other behaviour detrimental to one's own health.

Figure 42: Stronks conceptual model

Separating out the relative importance of these two explanations is no easy task because they themselves are highly interrelated. For example, smoking has a large impact in SES differences in life expectancy because of two factors: it is clearly implicated in premature deaths, and it is increasingly heavily concentrated in lower socio-economic classes, at least in the industrial west. *The Black Report* showed that more than twice as many women in

the lowest SES classification were smokers as in the highest (Feinstein, 1993).

In a unique paper, Stronks et al. attempt to answer the question of the relative importance of the cultural/behavioural and materialistic/structural explanations, while recognising their interdependence. They base their empirical work on the theoretical model displayed above (see Figure 42), which postulates that the behavioural and materialist explanations cannot be conceptually separated; both intervene between the SES of an individual and their health outcome. The model posits three social pathways between SES and health: 1) a direct relationship between behaviour and health; 2) a direct pathway between structure and health; and 3) the indirect structural effects that manifest themselves through behaviour. Again using the example of smoking rates, in this model one must account for the structural reason why lower socio-economic classes should smoke at higher rates. Because of Stronk's et al.'s theoretical model and their empirical work based upon it, they believe that the importance of behavioural aspects to SES and health outcomes can only be ascertained once structural factors have been controlled. Further, they conclude when such control is implemented that the role of behavioural causes of SES differential mortality has been greatly overstated. Stronks et al.'s empirical analysis shows that most socio-economic mortality differentials can be explained either by

structural causes or by behavioural factors influenced by underlying structure, with only a very limited amount being caused by behavioural factors not influenced by structure (Stronks et al., 1996).

A number of other studies have been consistent in their findings that although much can be explained by increased smoking rates or other lifestyle and behavioural "choices", even when these factors are controlled for, a significant portion, usually about half, still remains. Stronks et al. go a step further, arguing that controlling for the behaviour is not enough because some behaviours are themselves largely structurally dependent. Therefore, to assign a percentage of blame to a given behavioural cause ignores the structural foundation of the behaviour (Stronks et al., 1996).

There are of course those who take the counter view that far too much emphasis has been placed on structure and that there should be more individual accountability for health behaviour. For those who believe in structural causes this view is often classified as victim blaming. Some authors believe that many individuals act irresponsibly, choosing to ignore or treat as irrelevant their personal responsibility for the state of their own health, and thereby making one person's freedom of choice on health behaviour another person's burden through increased taxes and stress on the health care system (Crawford, 1977).

This point of view seems to come about because of the perception that structural causes of SES differential mortality are largely unfair (in a social justice context) and in need of government intervention. Behavioural differentials are seen as free choice, and those who behave unwisely bear the consequences of their own poor behavioural choices.

This view tends to be the dominant one among lay people on the causes of, and therefore the lack of injustice pertaining to, SES mortality differentials (Stronks et al. 1996). Ultimately, however, if there is a clear relationship between structure and behaviour then the behavioural patterns of an individual are not purely of free will but largely determined by their place in society.

A final theory closely aligned with the behaviourist explanation comes from the field of health economics. Put forward by Fuchs in a number of articles it is usually known as time preference theory. Fuchs believes that the link between education and favourable health outcomes can be explained by a single unobservable variable - the rate at which individuals discount the future (Feinstein 1993). In other words, the rate at which individuals are willing to invest now for future rewards varies greatly. It is this single trait that Fuchs believes has a significant impact on the total amount of education one will receive. Education, at its most pragmatic level is, in Fuchs view, a sacrifice in the present for greater future rewards.

As an economist, Fuchs would of course view this in strictly economic terms, using the economist's favourite assumption, "the rational man". Under these conditions, he is no doubt correct. The medical school student at the age of 30 is far behind the high school drop-out in terms of lifetime earnings, but shortly thereafter he will surpass his counterpart and go on to out-earn the other for the rest of his life by many fold. Fuchs extends this principle to behaviours that affect one's health. The decisions to smoke, abuse alcohol, follow a poor diet or not exercise are all easier, in the short term, than their alternatives. However a certain segment of the population makes a decision that the long-term costs are simply too great, and are willing to make the sacrifice today (stop smoking) to avoid the potential health consequence (lung and heart disease) decades in the future. For others, Fuchs argues the benefits appear too small and too far away, and they choose therefore to participate in the health adverse behaviours (Fuchs, 1979).

Fuchs' work has not been extensively empirically tested, but in the small pilot studies that he conducted respondents were asked a series of time discount questions, usually based on a monetary amount forgone in the present for some future amount. After a series of this type of questions to determine an individual's personal discount rate, correlations were then made to a series of health questions regarding behaviours such as smoking, weight and

seat belt use. Although the findings are based on small samples, the results do support Fuchs' thesis (Fuchs 1986).

While Fuchs' work has some "victim blaming" overtones it at least seems to search for a middle ground in that it attempts to explain why some individuals make what are, in the eyes of others, poor health decisions. Moreover, while blaming individuals will not alleviate the behaviour, an understanding of why individuals participate in health adverse behaviour would be a first step to devising an education programme that would be effective in helping them make better choices.

CHAPTER 8

CONCLUSIONS

This paper has dealt with how different socio-economic variables perform in displaying socio-economic differences in life expectancy. In general, it was found that this phenomenon was extremely robust with most of the variables tested showing substantial mortality differentials.

Of all the variables, the income classification performed best (showing the largest differentials) with the variable median income performing best of all. The education variables tested here also performed quite well. Of all the categories tested occupational classifications were the biggest disappointment. This poor performance was probably caused not by lack of occupational differentiation itself, but by the broad classifications that had to be

used with the available census data. While the quaternary or information sector did perform well, manufacturing and primary industry performed particularly poorly. From this we conclude that occupational analysis is probably best done at the individual and longitudinal level.

Housing statistics performed relatively well in showing differences in life expectancy, with the "need of major repair" variable performing exceedingly well.

The variables in the social category were the most diverse, as were the results. Those census tracts that contained large proportions of previously identified at risk groups, such as families headed by only one parent or children born to single mothers, showed substantial differences in life expectancy. The marriage variable and several others also showed significant mortality differentials. Some of the variables in this category did not perform very well, especially those surrounding religious affiliation, and again it is proposed that these variables may perform better at the individual level.

Therefore, it is concluded that one can select from a wide range of SES indicators depending on the data one has at hand and still be relatively certain that one will capture the phenomenon of differences in life expectancy if indeed it does exist.

The study of infant mortality showed that infant mortality differentials did persist between socio-economic groups. However any claim that infant mortality makes up a

significant component of the entire SES mortality gradient is not confirmed by the findings here.

In terms of the elderly, it was found that the vast majority of SES differentials had been overcome late in life and in some cases the SES differential was actually reversed. We concluded that this is probably due to the small number of remaining years of life. The exact degree to which the differential is reduced and the precise age at which this occurs probably depends on the variable used and the population studied.

The question of which low SES individuals make it to these advanced ages, and why, would be an interesting area for future research. It may be that they do not participate in some of the high-risk behaviours often associated with their SES status, in which case it could be concluded that low SES individuals who abstain from high-risk behaviour could largely avoid the risk associated with that status. This would contribute further to the structuralist-behavioural debate outlined earlier.

With regard to the persistent gender gap whereby SES mortality affects women to a lesser degree than men, some fresh theories have been put forward. In the Finnish study, identifying marriage rates as a confounding variable for high SES women did offer a plausible explanation, although it appears not to be applicable to the Ontario situation where the gender differential persists but the confounder does not. Further, given that both this study

and the Finnish study ruled out choice of variable as a potential explanation for the gender gap in SES mortality, that leaves differences in the cause of death structure as the only posited explanation from the Finnish study yet to be tested. This could be done in a Canadian context, to determine whether that explanation could be responsible for the much shallower gradient in female SES differences in life expectancy.

With regard to the multiple regression model attempted during this analysis, one cannot help but feel that the multi-collinearity problem hampered the quality of the results generated, since it was not possible to choose freely between all the variables that were tested in the earlier sections. Moreover, while a model with a relatively high R^2 could be constructed, it is seriously questioned whether this methodology is useful in this type of analysis.

However, it was clearly stated that our primary goal in using the model was to test for additional effects spatial. In many ways, the results generated by the place analysis with the use of dummy variables were quite informative. They confirmed that most, in this case eight out of ten, of the Ontario CMAs' health outcomes as measured by YLL/PYL could be predicted by their socio-economic profile, as defined by this model. Only the very high and very low health outcome communities fell outside the predictive capabilities of this model. These results

could be interpreted in two ways. If one places confidence in the model one could conclude that the life expectancy or health outcome of a community could be predicted by its socio-economic profile. The few notable exceptions at the high and low ends of the spectrum could then be looked at individually to see what makes them exceptional in terms of their health outcomes. Alternatively, if one does not believe that the model-building process can capture sufficient data to fully measure a community's SES profile, one could simply conclude that a better model would have been able to capture the outlying communities as well.

An interesting follow-up to this would be to study the cities that fell outside the model in terms of behavioural patterns that were not included in the SES analysis. Behaviours such as smoking patterns or alcohol consumption could be studied drawing on data from a source such as the Ontario Health Survey. Unfortunately, as is so often the case in Canada, much of the Ontario Health Survey is not susceptible to being studied at the CMA level, because of inappropriate geographical coding.

In general, it was felt that many of the characteristics studied would have been better examined at the individual as opposed to the ecological level. Moreover, while it has been demonstrated repeatedly that useful work can be done at the ecological level, many of the socio-economic variables studied here are very personal in nature, as is mortality itself. While it is certainly

true that environment can influence health outcomes it must be said that the vast majority of this type of work has been done at the ecological level because it had to be, not because it was best done at the ecological level. This is true not only of this current study but also of the vast majority of this type of research in Canada.

In fact, much of what we believe to be true about individual SES mortality in Canada is extrapolated from individual studies done elsewhere, using the logic that if our ecological study results match theirs then our individual level ones would as well - if we had any. There is a distinct lack of individual level SES mortality data in Canada. Further, much of the ecological work performed in Canada is performed on huge geographical units, such as public health units or census divisions, which are not homogeneous. It is only recently that the painstaking work of some at Statistics Canada has succeeded in breaking down these much larger groupings into the considerably more ecologically sound census tract level. As long as this type of data inadequacy exists in Canada, it is clear that Canadian research in this area will continue to lag behind research in other countries.

The phenomenon of SES mortality has now been clearly demonstrated many times and in many places over a wide range of methodologies. There would seem to be very little to be gained from doing further replicative studies that simply purport to confirm the phenomenon's existence.

Normative and descriptive studies that simply reinforce the dozens of studies that have gone before are no longer required. The modest contribution of this current study, showing that the phenomenon is robust over such a wide range of variables, should also bring to an end the agonising over the choice of variable. Any theoretically sound available socio-economic variable would seem to be capable of showing the phenomenon. Furthermore, while there is little doubt that different variables represent different constructs of SES, this characteristic is often not required for the overall measurement of socio-economic mortality differentials.

In view of the above, there seem to be only two plausible reasons to pursue this type of research in the future. The first is to monitor whether the gap or gradient of socio-economic mortality is changing. To ensure compatibility of findings it is recommended that a standardised methodology be devised and that this methodology be applied at different intervals, say census years, to check the progress of socio-economic mortality differential. This is in large part what Wilkins has done from 1971 onward and may be, in a Canadian context, all that is required to monitor this phenomenon in the years ahead. Of course, one problem with using Wilkins' method is that the LICO statistic is not widely available internationally, and even if it were, different countries tend to use different definitions for their poverty or low-

income lines. It may be necessary to go backward, choosing a universal statistic such as median income, applying this statistic to Canada and then comparing these results in the international context to compare differentials over both time and space.

The second major reason for continuing the study of socio-economic mortality differentials is to go far beyond the normative and descriptive that are the ending point for most of the current studies. Further studies must be able, by the very nature of their data or methodology, to explicitly contribute to the explanation of the phenomenon. The work of Stronks et al., which is clearly focused on explanations, is an example of the future direction this debate could most fruitfully take.

The work of Fuchs, who looks at time discounting by different individuals, also holds some future promise. His theoretical work could be built upon by directly tying it to some type of morbidity or mortality research, such as the addition of time discounting questions on the next Canadian or Ontario Health Survey. Even the Finnish study on the mortality gradient differences between genders, although not generalisable to an Ontario context, did make a diligent effort to explain the causes underlying the shallower female gender mortality gradient that so many have simply noted and made no attempt to explain. It is in

these types of studies that Canada's lack of detailed individual and longitudinal data, and the way it is made available, mean that Canadian researchers are extremely poorly positioned to answer the deeper explanatory questions that have yet to be tackled in this area.

In general, the ecological data that are widely available in Canada is more suited to hypothesis generating than to the deeper analysis called for here. It is argued that the phenomenon looked at here is clearly established. The socio-economic mortality gradients exist. The question now to be answered is "Why?" The strength of data collected at the individual level, if properly coded, is that it can be grouped up to census tract, public health unit or city level to answer important ecological questions. Information available only at the ecological level cannot be disaggregated to answer questions at the individual level. Therefore, if one wishes to determine whether this analysis is best done at the individual or the group level, one cannot answer this from ecological data alone. Moreover, while the literature on this phenomenon moves forward to try to explain why socio-economic differences in life expectancy persist, the current data deficiencies make it unlikely that these deeper explanations will come from Canadian sources.

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APPENDIX A

An example of the life tables generated for each SES variable.

Age Group										
Population	Deaths	Age Interval	(years)	$\frac{M}{A}$	$\frac{G}{A}$	$\frac{I}{A}$	$\frac{D}{A}$	$\frac{L}{A}$	$\frac{T}{A}$	$\frac{E}{A}$
10315	53	1	0-1	0.00514	0.00511	100000	511	99545	8158770	81.55
40335	5	2	1-4	0.00012	0.00050	99489	49	397844	8059225	81.01
50530	7	3	5-9	0.00014	0.00069	99439	69	497007	7661391	77.05
48920	3	4	10-14	0.00006	0.00031	99370	30	496795	7164375	72.10
49615	22	5	15-19	0.00044	0.00221	99340	220	496204	6867579	67.12
51155	11	6	20-24	0.00022	0.00107	99120	107	495333	6171375	62.26
61830	21	7	25-29	0.00034	0.00170	99013	169	494647	5676042	57.33
67075	25	8	30-34	0.00037	0.00196	98845	184	493776	5181395	52.42
63820	30	9	35-39	0.00047	0.00235	98651	232	492751	4687619	47.51
61305	59	10	40-44	0.00095	0.00472	98430	465	491057	4194989	42.62
46635	91	11	45-49	0.00196	0.00971	97865	952	487637	3703812	37.81
37130	100	12	50-54	0.00269	0.01339	97014	1299	482082	3218175	33.15
32060	166	13	55-59	0.00615	0.02543	96715	2434	472977	2734093	28.56
29210	198	14	60-64	0.00678	0.03336	93281	3112	458092	2261116	24.24
25840	290	15	65-69	0.01122	0.06464	90169	4927	438020	1802024	19.98
17435	317	16	70-74	0.01818	0.08718	85242	7432	408745	1363004	15.95
11920	358	17	75-79	0.03003	0.13989	77810	10984	362396	954259	12.26
6820	383	18	80-84	0.05762	0.26184	68926	16855	292495	581873	8.84
3090	382	19	85-89	0.11715	0.45307	50072	22696	193643	296378	5.38
945	224	20	90-94	0.23704	0.74419	27386	20380	85979	105735	3.86
225	95	21	95+	0.42222	1.00000	7006	7006	19756	19756	2.82

Abridged Life Table, Urban Canada, Male and Female, 1991

Population	Deaths	Age Interval	Age Group						
			(years)	M_x	q_x	l_x	d_x	L_x	T_x
20255	127	1	0-1	0.00027	0.00024	100000	824	99437	7903832
69845	21	2	1-4	0.00030	0.00120	99378	119	397224	7704375
78735	12	3	5-9	0.00015	0.00076	99257	76	496088	7307151
73555	9	4	10-14	0.00012	0.00061	99181	61	495773	6811083
81240	48	5	15-19	0.00059	0.00295	99121	292	494902	6315289
116200	59	6	20-24	0.00051	0.00254	98829	251	493515	5820389
152425	112	7	25-29	0.00073	0.00367	98578	362	492021	5326873
135585	137	8	30-34	0.00101	0.00504	98216	495	489893	4834852
109770	136	9	35-39	0.00124	0.00618	97721	604	487187	4344959
95896	166	10	40-44	0.00173	0.00862	97118	837	483662	3867771
74620	214	11	45-49	0.00287	0.01425	96280	1372	478247	3374109
66660	311	12	50-54	0.00467	0.02308	94909	2190	469506	2855862
66940	488	13	55-59	0.00729	0.03584	92718	3323	455783	2426356
67200	783	14	60-64	0.01165	0.06674	89386	5072	435312	1970573
63570	1187	15	65-69	0.01967	0.09944	84323	7542	403894	1535261
45670	1251	16	70-74	0.02739	0.12868	76782	9880	360691	1131366
33550	1458	17	75-79	0.04346	0.19715	68902	13180	303512	770675
18110	1303	18	80-84	0.06818	0.29288	53712	15736	230792	467163
7865	908	19	85-89	0.11545	0.45200	37975	17185	148681	238371
2270	465	20	90-94	0.20485	0.68665	20810	14290	69757	87690
585	159	21	95+	0.26723	1.00000	6521	6521	17933	17933
1381575	9354								

Abridged Life Table, Urban Canada, Males, 1991

Population	Deaths	Age Interval	Age Group						
			(years)	M_x	q_x	l_x	d_x	L_x	T_x
10290	74	1	0-1	0.00719	0.00715	100000	715	99364	7455353
36735	13	2	1-4	0.00038	0.00145	99285	144	398818	7355989
40430	7	3	5-9	0.00017	0.00087	99141	86	495469	6959170
37760	6	4	10-14	0.00016	0.00079	99065	79	486131	6463701
41315	37	5	15-19	0.00090	0.00447	98977	442	483888	5968570
56350	47	6	20-24	0.00083	0.00418	98534	410	491648	5474892
76505	79	7	25-29	0.00103	0.00515	98124	505	489358	4983038
68255	98	8	30-34	0.00145	0.00723	97619	705	486366	4493678
54445	92	9	35-39	0.00189	0.00841	96913	818	482610	4007312
46775	102	10	40-44	0.00218	0.01085	96098	1042	478040	3524701
35920	142	11	45-49	0.00385	0.01958	95066	1862	470995	3046661
31790	187	12	50-54	0.00588	0.02902	93194	2704	459748	2575668
31990	300	13	55-59	0.00938	0.04591	90489	4156	442890	2115918
31800	483	14	60-64	0.01518	0.07333	86334	6331	418786	1673028
28050	748	15	65-69	0.02670	0.12547	80004	10038	375828	1256233
19455	721	16	70-74	0.03708	0.17045	69968	11926	321803	880305
13730	841	17	75-79	0.06125	0.26630	58040	15456	252332	558502
7065	589	18	80-84	0.09752	0.39203	42584	16894	171183	306170
2635	380	19	85-89	0.14421	0.52988	25888	13721	95145	134897
580	170	20	90-94	0.29310	0.84577	12188	10292	35113	39842
230	57	21	95+	0.16087	1.00000	1877	1877	4729	4729
871095	5256								

Abridged Life Table, Urban Canada, Females, 1991

Population	Deaths	Age Interval	Age Group						
			(years)	M_x	q_x	l_x	d_x	L_x	T_x
9965	53	1	0-1	0.00532	0.00529	100000	529	99529	8134402
34110	8	2	1-4	0.00023	0.00094	99471	93	397674	8034873
38326	5	3	5-9	0.00013	0.00066	99377	65	496708	7637200
35795	3	4	10-14	0.00008	0.00042	99313	42	496488	7140491
39923	11	5	15-19	0.00028	0.00138	99271	137	496047	6644005
59850	12	6	20-24	0.00020	0.00100	99134	98	495423	6147958
75920	33	7	25-29	0.00043	0.00217	99035	215	494637	5652535
67330	38	8	30-34	0.00064	0.00282	98820	278	493418	5157897
55325	44	9	35-39	0.00080	0.00397	98541	391	491769	4664480
49120	64	10	40-44	0.00130	0.00649	98150	637	489264	4172711
38700	72	11	45-49	0.00186	0.00926	97513	903	485487	3683457
34870	124	12	50-54	0.00356	0.01784	96610	1704	479130	3197970
34980	188	13	55-59	0.00538	0.02656	94906	2521	468732	2719841
35400	300	14	60-64	0.00847	0.04155	92385	3838	452906	2250109
35520	438	15	65-69	0.01233	0.06888	88547	5302	430008	1797202
26215	530	16	70-74	0.02022	0.08650	83245	8033	397345	1387193
19820	617	17	75-79	0.03113	0.14462	76211	10877	349407	989849
12045	614	18	80-84	0.05088	0.22607	64334	14644	285311	620441
5220	528	19	85-89	0.10098	0.40305	49790	20088	198781	335130
1690	285	20	90-94	0.17456	0.60782	29722	18060	103461	136349
365	122	21	95+	0.33425	1.00000	11662	11662	32888	32888
710480	4099								

APPENDIX B

Correlation matrixes for the SES variables and the two dependent variables, life expectancy and YLL/PYL.