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General and Cause-Specific Adult Mortality Among Immigrants in Canada, 1971 and 1981

Frank Trovato
University of Alberta
Edmonton, Alberta, Canada
and
Clifford C. Clogg
The Pennsylvania State University
University Park, PA, U.S.A.

Abstract

Much emphasis has been devoted to the adjustment and adaptation of immigrants in Canada, but we know very little about their mortality experience. In this study, we examine general and cause-specific mortality for American, English, Scottish, Italian and other foreign-born immigrants in relation to the Canadian-born population for the census periods, 1971 and 1981. Results from a Poisson regression analysis, based on log-rate models for relative mortality risk, reveal limited support for the hypothesis that the life stresses of the migration experience lead to an increased risk of death due to suicide, homicide and accidents among immigrants. The prediction that discrepancies in socioeconomic status are of importance in explaining mortality differentials gained partial support. In general, immigrants fare better than their host population with respect to the risk of overall mortality, but in 1971 they suffered increased odds of dying from neoplasms. Concerning other causes, the results tend to be mixed, but Italians, followed by the English experience the lowest levels of mortality, while the residual class of migrants (other foreign-born) and the Canadian-born tend to suffer elevated odds. The Scottish and Americans have an intermediate risk. Overall, the findings are consistent with the literature based on other immigrant societies, that the foreign-born generally experience better survival probabilities than their host countries.

Résumé

On s'est beaucoup intéressé à l'adaptation des immigrants au Canada, mais on a peu étudié leurs statistiques de mortalité. La présente étude examine la mortalité générale et spécifique chez les immigrants d'origine américaine, anglaise, écossaise, italienne et autres par rapport à la population d'origine canadienne durant les périodes de recensements de 1971 et 1981. Les résultats d'une analyse de régression conforme à une loi de Poisson et fondée sur des modèles de distribution logarithmique des risques de mortalité ne confirment guère l'hypothèse voulant que les tensions de l'immigration entraînent une augmentation des risques de décès dus aux suicides, aux homicides et aux accidents parmi les immigrants. Ils confirment partiellement les prévisions soutenant que les écarts socio-économiques peuvent expliquer certaines différences. En général, les immigrants ont un meilleur sort que la population hôte en ce qui concerne le risque de mortalité globale mais, en 1971, ils couraient de plus grands risques de mourir de néoplasmes. Quant aux autres causes, les résultats sont plus ou moins mitigés mais on note les taux de mortalité les plus bas chez les Italiens, suivis des Anglais; parmi les autres immigrants et les Canadiens d'origine, les risques tendent à être supérieurs. Le risque est intermédiaire chez les Écossais et les Américains. Dans l'ensemble, les résultats sont conformes à ceux de la littérature fondée sur les autres sociétés immigrantes et concluant que les personnes d'origine étrangère jouissent en général d'une meilleure probabilité de survie que la population de leur pays hôte.

Key Words: mortality, immigrants, cause of death, Poisson regression

Introduction

This study focusses on demographic and sociological aspects of immigrant mortality in Canada during the census periods of 1971 and 1981. Out of the 25 million people in Canada during 1981, four million, or approximately 16%, were of foreign birth. Much emphasis has been placed on this important component of the Canadian population with regard to their adjustment, adaptation and assimilation processes (for example, Richmond, 1967; Kalbach, 1970; Richmond and Kalbach, 1980), but only scant attention has been directed to their mortality experience. The mortality of the foreign-born in host countries can provide important clues concerning epidemiological, demographic and sociological processes. For example, epidemiologists often rely on studies of immigrants to assess possible genetic and environmental factors in the etiology of disease (Haenszel, 1961, 1975; Stawszeski *et al.*, 1970; Lilienfeld *et al.*, 1972; Marmot *et al.*, 1984a; Kasl and Berkman, 1985). Sociologically, studies of migrants' mortality patterns and differentials can shed light on how well they adapt to the challenges associated with relocation (Young, 1987).

The Canadian literature seems to be consistent with much of the documented evidence in these other societies. By and large, the foreign-born tend to have lower or comparable general mortality levels in relation to the native-born population (Trovato, 1985, 1986; Kliewer, 1979).

The American evidence suggests that prior to the Second World War, immigrants exhibited disproportionately high odds of mortality (for example, Dublin *et al.*, 1949; Dublin and Baker, 1920; Dublin, 1933; Jacobson, 1963), whereas in recent decades there is evidence of a reversal, with the foreign-born showing lower death rates than the native-born, in both general and broad causes of death such as cancers, cardiovascular, heart disease, and external complications (Kestenbaum, 1986). In an earlier study based on data for 1960, Kitagawa and Hauser (1973) found virtually no difference in overall risk between foreign and native-born populations in the United States.[1]

In France, Brahimi (1980) determined that during 1974-75, immigrants generally possessed a superior level of survival than persons born in France. The more recent immigrant groups had lower death rates than their more established counterparts. It was discovered that in relation to French males, males born outside France had reduced mortality levels from cardiovascular complications, cancers, alcoholism and suicide, but showed a higher risk from accidents and violence. Females born outside France had higher risks from cardiovascular related problems,

cerebrovascular complications, respiratory ailments, and accidents and violence than the native-born females.

In Australia, Burwill and associates (1973) studied deaths from suicide, motor vehicle accidents, and all other forms of violent deaths combined among immigrants and the Australian-born population during the period 1960-66. The rates were observed to be highest among the foreign-born. However, in a different study Stenhouse and McCall (1970) discerned that as far as cardiovascular disease mortality is concerned, immigrants tend to posses a lower overall risk than persons born in Australia. Recently, Young (1987) corroborated earlier findings by showing that in the case of external causes of death, the foreign-born (with some exceptions) continue to show higher rates than the native-born in Australia, and that in connection with degenerative and chronic diseases, immigrants tend to do better than the host population.

In England and Wales, Marmot and colleagues (1983; 1984a; 1984b) found that in comparison to the host society, immigrants tend to display lower risks from overall mortality and from a number of specific causes of death, but some groups tend to do better (for example, Italians, Spaniards, French, Australians, Canadians, West Germans and New Zealanders) than others (for example, Irish, Scottish, African Commonwealth). Death rates from accidents and violence are higher across all immigrant groups, however.

Objectives of the Study

Two questions concern us the authors of this paper. First, what is the relationship between nationality and mortality in Canada for general and specific causes of death, and how has this relationship changed between 1971 and 1981? Past studies in Canada have tended to focus on the situation up until 1971 (Trovato, 1985; Kliewer, 1979). A problem associated with previous research is that only a limited number of variables, such as age and sex, have tended to be included in the statistical analyses. Typically, analysts rely on age standardization and seldom control for additional variables. In this study, the authors introduce controls for age, sex, marital status and age-sex compositions simultaneously, and also include a measure of economic standing to study mortality differences among immigrants.[2]

The authors also wish to link the idea of life stresses to immigrant mortality. The experience of migration is generally a positive development for most persons, but in many ways it is also a stressful process. The effects of life stress may be reflected in migrants' higher mortality levels

from causes of death that are typically associated with distress and conflict in life, for example, suicide, accidents and homicide.

Nativity, Socioeconomic Status and Mortality
There is considerable variation in socioeconomic status (SES) among immigrants in Canada as measured by income, education and occupation (Porter, 1965; Richmond, 1967; Richmond and Kalbach, 1980). Traditionally, persons from Anglo-Saxon origins have fared better than immigrants from other cultural origins, but in recent decades individuals from other backgrounds have made significant socioeconomic progress (Richmond and Kalbach, 1980).

Unfortunately, there exists no information concerning how this fact may relate to the mortality experience of immigrants in Canada. The international literature leads us to anticipate that there will be an inverse relationship between measures of SES and mortality (Antonovsky, 1967; Preston, 1977; Benjamin, 1965; Stockwell, 1963; Berkman and Syme, 1979; Fein, 1977; Dutton, 1978; Powels, 1978; Duleep, 1989; Kitagawa and Hauser, 1973). Thus, a control for SES is an important aspect of this analysis. We are not certain, however, what will be the direction of effects when immigrants are compared to the Canadian-born.

Life Stresses and Immigrant Mortality
There is an established body of literature which documents the relationship between difficulties in life, susceptibility to illness, and mortality (Syme and Berkman, 1976; Berkman and Syme, 1979; Casel, 1974; Cobb, 1976; Cohen and Brody, 1981; Marmot and Syme, 1976), and also how the influence of stressful events, such as migration, relate to morbidity and mortality (Hull, 1979; Rahe, 1979; King and Locke, 1987; Locke and Duvall, 1964; Kasl and Berkman, 1985; Krupinski, 1967; London, 1986; Whitlock, 1971; Antonovsky, 1971; Evans, 1987; Vega *et al.*, 1987; Trovato and Jarvis, 1986; Odegard, 1932). This literature supports the idea that migration is a form of rapid change — a significant alteration in life for the individual — involving many challenges and adjustments in the adopted environment, such as establishing residence, finding new employment, and learning the new language of the host society.

To the degree that prolonged stress is related to psychological disability and morbidity in general, there may be an increased risk of mortality due to suicide and accidents among migrants. Homicide also may be a manifestation of this phenomenon, although in less obvious ways, as in the case of suicide. Although the mechanisms involved are undoubtedly

complex, according to Gove (1973), homicide mortality must reflect, in part, conflict, frustration and dissatisfaction in the victim's life.

Many foreigners in host countries have been observed to display above average mortality risks from external causes of death such as suicide, homicide, motor vehicle accidents and other kinds of accidental fatalities (Young, 1987; Shai and Rosenwaike, 1988; Rosenwaike and Shai, 1986, 1989; Rosenwaike, 1987; 1983; Brahimi, 1980; Smith *et al.*, 1986; Whitlock, 1971; Burwill *et al.*, 1973; 1982; Marmot *et al.*, 1984a). The generality of this association suggests that excess mortality from these external causes of death is a manifestation of high degrees of stress (and distress) in the lives of immigrants.

The hypothesis of life stresses predicts higher migrant rates for external causes of death in relation to the receiving society. Ideally, this thesis requires prospective micro-data on migrants with regard to many variables such as age at immigration, lifestyle, health habits, risk-taking, adherence to ethnic culture, and so on. The present study cannot provide a direct test of the hypothesis. Such data are non-existent in Canada. Therefore, this paper is confined to an indirect approach by observing the extent to which the results of the analysis, based on vital statistics and census data, conform to expectations consistent with the life stresses thesis.

Although this hypothesis predicts higher rates among foreigners, it is important to note that not all immigrant groups exhibit above average risks of death due to external causes. For example, in the case of suicide, Italians in Canada and in other parts of the world show a relatively low risk (Trovato and Jarvis, 1986; Young, 1987; Marmot *et al.*, 1984a).

An important intervening mechanism between life stresses and death from suicide and other types of violent and accidental death may be the degree of social support available in the receiving immigrant ethnic community (Tran, 1987; Trovato and Jarvis, 1986). The greater the level of cohesiveness and institutional completeness, the greater the level of social supports available for the individual immigrant. The ethnic community may serve to buffer the difficulties and psychological distress newcomers may experience in their new society. The ultimate effect of this phenomenon may serve to lower the risk of accidents, violence and suicide for the person who is cohesively integrated into his/her ethnic community.

It is anticipated that groups that are known to possess high degrees of institutional completeness are also likely to share high levels of informal ties among members and consequently will demonstrate a relatively low

incidence of mortality, particularly from suicide and other forms of violence and accidents. Based on the work of Breton (1964) and Reitz (1980) and the present authors' knowledge of ethnicity in Canada, it is hypothesized that the level of community integration is highest among South Europeans (such as Italians, Greeks and Portuguese) and lowest among Anglo-Saxon origin groups (such as Americans, English, Scottish and Welsh), and that mortality from external causes would tend to follow this ordering.

Data and Methods of Analysis

The mortality statistics for this study come from two different sources for two census periods, 1971 and 1981. The deaths were taken from the Canadian Mortality Data Base housed at Statistics Canada in Ottawa. The denominators were taken from the Canadian censuses 100% file. We first compiled a data set containing death counts for 11 causes cross-classified by period, country of birth (U.S.A., England-Wales-Northern Ireland [English], Scotland, Italy, Other Foreign- Born, Native-Born, and Missing Country of Birth), sex (male, female), age (15-29, 30-39, 40-49, 50-59, 60-69, 70+) and marital status (single never married, married, other). The number of cells in this tabulation is 5544. From the census tapes, the authors extracted relevant denominator counts crosstabulated in exactly the same way as the death frequencies. This information was then appended, as well as age-sex-marital-status-nativity specific data on household income, percent university educated, and percent unemployed, to the mortality file to form one integrated data set. These three socioeconomic variables were combined into a composite index of socioeconomic status with the use of factor analysis.[3]

The nationality groups selected in this study represent significant demographic and sociocultural entities in Canada. The English and the Scottish share a long tradition of immigration to Canada which began during the formative stages of this nation. They are both of Anglo-Saxon origin, which is the dominant culture of this society. United States immigrants in Canada share a number of similarities to these two groups in that they also tend to be predominantly of Anglo background. Given these similarities, one would surmise that these groups' mortality levels and patterns will approximate closely those of the Canadian-born. The Italians are distinctly different in both origin and cultural background. They are relative newcomers to Canada, as most of them immigrated during the late 1950s and early 1960s. Another distinct feature of this group is its relatively low degree of own language loss and a strong retention of ethnic identity, supported by their high levels of institutional completeness (Breton, 1964; Reitz, 1980; Darroch and Marston, 1984).

The Canadian-born population is used as a standard for the purpose of making comparisons across immigrant groups. This subpopulation is necessarily a very heterogeneous class containing persons of varied ethnic backgrounds, and, undoubtedly, many individuals in this subgroup are descendants of immigrant parents.[4] The Other Foreign-Born group (OFB) is a residual class also consisting of a heterogeneous collectivity of nationalities and ethnic cultures.[5]

The Missing Country of Origin category reflects decedents for whom no country of birth information was recorded on the death certificate. During the three year period 1970-72, the number of such cases was only 2% (9,376) of the total number of deaths (447,361). During the 1980-81 interval, the number of "missing" increased to 24% (78,342) of the total number of deaths (321,342).[6]

A common strategy in coping with this situation is to simply remove the missing cases from the analysis. Such a decision cannot be justified when the number of "unknowns" is large. Another approach would be to apportion the missing on the basis of the known distribution of deaths. To do so in the present case is inappropriate, as one would have to assume that the missing have the same underlying distribution and characteristics as the known cases. The authors think this is a highly questionable assumption given the large number of missing.[7]

It was decided to explicitly include the cases with a missing country of birth into the statistical analysis by treating them as an additional category of national origin. In doing so, it is possible to derive net effects of variables so long as one focusses on differences (contrasts) that are well-defined. For example, the authors include the missing category and put in an arbitrary number for the corresponding exposures for the known countries of birth on mortality adjusted for the potential confounding effects of missing nationality.[8]

A common procedure in these types of studies is to compute death rates standardized for age composition and then proceed to discuss differentials on the basis of standardized mortality ratios. This approach does not fully exploit the available information. The authors apply log-linear methods appropriate for the analysis of rare events, Poisson regression, which assumes that deaths are independent rare events randomly distributed over some interval of time, with an underlying probability of death being small in relation to the number of people exposed to the risk of dying. The exponential property of the Poisson distribution dictates that the natural parameter characterizing it is the logarithm of the death rate (Feller, 1968;

Clogg and Eliason, 1987; Agresti, 1990). Therefore, the log-linear link is used to specify a hazard model for the death rate (Laird and Olivier, 1981) of the form:

$$\log\left[\left(\frac{D_{ijkl}}{E_{ijkl}}\right)\cdot\left(\frac{PS_{ij}}{\Sigma PS_{ij}}\right)\right] = \lambda + \Sigma B_{Age} + \Sigma B_{Sex} + \Sigma B_{Marital\ Status} + \Sigma B_{Country\ of\ Birth} + B_{SES} + \Sigma B_{SES \cdot Country\ of\ Birth} + \Sigma B_{Other\ Interactions}$$

where:

D_{ijkl}	=	the death counts for age group *i*, sex group *j*, marital status *k*, and nationality group *l*,
E_{ijkl}	=	the population exposed to the risk of death for age group *i*, sex group *j*, marital status group *k*, and nationality group *l*,
PS_{ij}	=	a standard population (England and Wales, 1911) in age group *i* and sex group *j*,
PS_{ij}	=	the sum of PS_{ij},
λ	=	the intercept term in the equation (baseline hazard),
B	=	the amount by which the death rate changes for a unit change in a given independent variable, while other terms in the equation are held constant.

Note that the term on the left side of the equation is the age-sex standardized mortality rate, and the terms on the right are log-linear parameters.[9] To the authors' knowledge, this combined use of standardized rates and Poisson regression is new, but it has been suggested in a footnote by Clogg and Eliason (1988:271).

Relevant log-rate models were computed to find one that fit the data well. The authors then proceeded to ascertain whether the parameter terms in the model support the hypotheses developed earlier. The R^2 analogue (R^2A) was used to gauge goodness of fit, defined as $1-(L^2/L^2B)$, where L^2B is the baseline log-likelihood-ratio statistic and L^2 is the analogous statistic for an alternative model. These authors consider a good fitting model to be one which lowers the baseline log-likelihood chi-square by at least 90%, where the baseline model includes just the effect of age. Note that if a baseline with just the intercept term has been used, the fitted models would most certainly account for 99% of the explained variance in the death rate.

Results

Crude rates, as well as the geometric means of each group's age-specific rates, are displayed in Table 1. The geometric mean is useful in making group comparisons in death rates (Schoen, 1970). In 1971, the native-born possessed the highest risk of death, with a geometric mean of 6.69 per thousand, while the Italians and the English foreigners had relatively low levels of mortality (3.84 and 4.54, respectively). In 1981, the geometric means declined considerably for all subgroups. The Italian (2.20) and English (2.62) immigrants continue to show the lowest risks, while the Canadian-born persisted in showing the highest levels of mortality. The differentials in the table are considerable and warrant further analysis. Age standardized differentials by cause of death are also substantial (table not shown, but available on request).

Table 2 displays the final log-rate models selected for general and cause-specific mortality for 1971 and 1981. The table gives the relevant terms in the chosen models along with their independent contribution to reducing the baseline L^2 statistic.[10] An important result in the table is that with the exception of four causes of death in 1981 — certain degenerative diseases, homicide, suicide, and other accidents-violence — country of birth is the most important term explaining differences in mortality. One may also note that the socioeconomic terms and the SES-nationality interactions in the models explain only a modest degree of variation, and, in a number of cases, the main effects of these variables failed to enter the equations.

TABLE 1. DISTRIBUTION OF DEATHS, CRUDE RATES, AND GEOMETRIC MEANS OF AGE-SPECIFIC DEATH RATES BY COUNTRY OF BIRTH*

	Deaths (%)		Central Crude Rates (per 1000)		Geometric Means (per 1000)		Geometric Mean Differences From The Canadian Born	
	1970-72	1980-81**	1971	1981	1971	1981	1971	1981
COUNTRY OF BIRTH								
United States(USA)	16659 (3.7)	9047 (3.8)	20.94	16.50	6.17	4.10	- .52	- .52
England-Wales-N.Ireland(English)	40750 (9.1)	16113 (5.0)	20.60	12.39	4.54	2.62	- 2.15	- 2.00
Scotland	15263 (3.4)	6399 (2.0)	24.73	17.11	6.38	4.08	- .31	- .54
Italy	5239 (1.2)	5239 (1.6)	4.92	6.89	3.84	2.20	- 2.85	- 2.42
Other Foreign Born(OFB)	62824(14.0)	31114 (9.7)	15.02	8.19	6.38	3.27	- .31	- 1.35
Canadian Born (CB)	297251(66.4)	177142(55.1)	8.14	5.91	6.69	4.62	---	---
Missing Nationality	9376 (2.1)	78342(24.4)	.21	2.16	.16	1.38	---	---
TOTAL DEATHS AND RATES	447362(100.0)	32142(100.0)	10.11	8.75	6.59	5.68		

* Data pertain to persons 15 years of age and older.

** In this and subsequent tables, the death counts for 1981 pertain to 1980-81 deaths, as at the time of data compilation deaths in 1982 had not been entered into the Mortality Data Base. In effect, the rates for this period pertain to 1980.5.

TABLE 2. SELECTED BEST-FITTING LOG-RATE MODELS FOR GENERAL AND CAUSE-SPECIFIC MORTALITY, 1971 AND 1981, AND TERMS' CONTRIBUTION TO THE EXPLAINED LIKELIHOOD-RATIO CHI-SQUARE IN EACH MODEL

1971	MODEL FITTED BY CAUSE OF DEATH								
	GENERAL	NEOPLASMS	CARDIOVASCULAR	CERTAIN DEGENERATIVE	HOMICIDE	SUICIDE	MOTOR VEHICLE ACCS.	OTHER ACCS.&VIOL.	RESIDUAL
	A[*] S[8380] M[16562] P[482256] F[759] FP[1333] AP[330] SP[6664] MP[148] AS[6447]	A[*] S[689] M[190] P[106460] F[113] AP[193] SP[75] MP[1923]	A[*] S[3117] M[9381] P[246804] F[3759] FP[124] AP[997] SP[391] MP[2834] AS[5281]	A[*] S[143] M[761] P[21852] F[9] FP[15] AP[194] SP[26] MP[246]	A[*] S[89] M[200] P[1521] F[1] FP[16] AP[22] MP[42] AM[96]	A[*] S[1242] M[620] P[9290] F[54] AP[94] MP[204]	A[*] S[3333] M[1147] P[16600] F[13] AP[82] MP[473]	A[*] S[2002] M[2500] P[17675] F[108] FP[204] AP[91] AS[1013] AM[207]	A[*] S[1545] M[5070] P[63455] F[81] FP[27] AP[459] SP[46] MP[558]
EXPLAINED	[522879]	[109643]	[272688]	[23246]	[1987]	[11504]	[21648]	[23800]	[71241]
DF	178	183	178	183	179	194	194	186	183
BASELINE	[532694]	[112229]	[277225]	[24380]	[2116]	[11928]	[22410]	[24849]	[73973]
DF	246	246	246	246	246	246	246	246	246
(R^2)	(.98)	(.98)	(.98)	(.95)	(.94)	(.96)	(.97)	(.96)	(.96)

1981

GENERAL	NEOPLASMS	CARDIOVASCULAR	CERTAIN DEGENERATIVE	HOMICIDE	SUICIDE	MOTOR VEHICLE ACCS.	OTHER ACCS.&VIOL.	RESIDUAL
A[*]	A[*]	A[*]	A[*]	A[*]	A[*]	A[*]	A[*]	A[*]
S[2586]	S[175]	S[474]	S[43]	S[59]	S[1508]	S[2461]	S[1109]	S[336]
M[64090]	M[8583]	M[31468]	M[3733]	M[477]	M[2847]	M[2384]	M[5175]	M[12252]
P[83149]	P[23489]	P[37218]	P[3113]	P[371]	P[2173]	P[3992]	P[3332]	P[10472]
F[392]	F[82]	F[1044]	F[48]	AP[26]	AP[42]	AP[80]	F[137]	F[24]
FP[761]	AP[967]	FP[38]	FP[8]	MP[42]	MP[700]	MP[1015]	FP[121]	AP[251]
AP[3226]	SP[820]	AP[3954]	AP[139]	AM[57]	SP[20]	SP[79]	AP[157]	SP[293]
SP[503]	MP[12521]	SP[91]	SP[24]	SM[30]	AS[87]	AM[92]	SP[73]	MP[2343]
MP[2999]	AS[442]	MP[13451]	MP[1399]	SP[7]	AM[238]	SM[62]	MP[682]	AS[255]
AS[3012]	AM[920]	AS[3026]	AS[298]		SM[159]	AS[243]	AS[517]	AM[878]
AM[3723]	SM[2690]	AM[1426]	AM[252]				AM[324]	SM[1283]
SM[8314]	SMP[4295]	SM[3526]	SM[465]				SM[180]	
SMP[20128]		SMP[11115]	SMP[915]				SMP[2758]	
EXPLAINED [219875]	[54992]	[106831]	[10437]	[1069]	[7774]	[10408]	[11807]	[31145]
DF 154	154	154	154	177	172	172	166	159
BASELINE [235405]	[59639]	[115678]	[10841]	[1241]	[8613]	[11499]	[13079]	[33215]
DF 246	246	246	246	246	246	246	246	246
(R^2) (.93)	(.92)	(.92)	(.96)	(.86)**	(.91)	(.90)	(.90)	(.94)

NOTES: (1) The terms are defined as follows: A=Age, S=Sex, M=Marital Status, P=Country of Birth, F=SES Index, FP=SES-Country of Birth Interaction, AP=Age-Country of Birth Interaction, SP=Sex-Country of Birth Interaction, MP=Marital Status-Country of Birth Interaction, SMP=Sex-Marital Status-Country of Birth Interaction.

(2) [*] = Baseline Variable

(3) The figures in brackets represent conditional contributions of each variable in the model to reducing the Baseline L^2.

(4) R^2 = R^2 analog; it measures the proportionate reduction of a given fitted model in the Baseline L^2.

(5) The cause of death "Certain Degenerative" consists of diabetes, ulcers of the stomach and duodenum, nephritis, and cirrhosis of the liver.

** The derived P-value for the model L^2 is .56, thus the model is a good fit even though the analog R^2 is less than .90.

It is important to indicate a potential problem in the results concerning the influence of SES on mortality. This measure of SES is ecological, computed from socioeconomic information in the census pertaining to each immigrant age-sex-marital-status grouping. Of course, based on the inverse mortality gradient with SES, decedents within a given group are likely to be predominantly of low SES, and therefore, there would be little variability in mortality within groups. However, since the main purpose in using the SES index is to ascertain between-group differences, this procedure is thought to be appropriate.

General Mortality

The nativity main effects in Table 3 indicate a declining mortality risk over the years. The largest reduction is enjoyed by the residual category of nativity (OFB). In both periods, the Italians and the English demonstrate the lowest risks. Immigrants from the United States were burdened with a considerable risk in 1971 (exp 0.641 = 1.9), which was second-highest, next to the OFB. In 1981, the Americans reduced their risk to third-highest among all groups.

In comparison to the Canadian-born, the influence of SES for immigrants generally contributes to a lowering of mortality risk over time. The negative contrasts increase over time, with the exception that for Italians, the SES effects tend to diminish over time. The reasons for this group's different pattern cannot be easily obtained. One may be able to gain some indication of possible underlying sources for this effect once the specific causes of death have been examined. It may be that for low mortality groups such as Italians, gains in SES increase the risk of death from certain ailments or from external conditions (such as accidents). In relation to the Canadian-born, all groups in 1971 (except OFB) experienced a reduction in death rates with gains in SES. The same situation occurs for 1981, except that as noted above, Italians increase their risk, and that for OFB the odds are reduced in comparison to 1971. Thus, with some exceptions, gains in economic well-being tend to reduce overall mortality risk among most immigrant groups.

Causes of Death

With regard to the country of birth main effects, two general features are worth noting at this stage of the analysis. First, the highest risks tend to be associated with other foreign-born and the native-born; secondly, all groups appear to have improved their survival chances across all causes over the 10-year study period. By and large, the lowest rates of death occur among the Italians, followed by the English immigrants.

TABLE 3. LOG-RATE EQUATIONS FOR GENERAL MORTALITY, CANADA

	1971		1981	
TERM	PARAMETER	Z	PARAMETER	Z
λ	-6.4775	---	-7.3157	---
AGE				
15-29	-1.0004	-43.50	- .9218	-24.91
30-39	- .9091	-37.88	- .6015	-16.50
40-49	- .2125	-15.68	.1181	3.94
50-59	.2536	21.23	.3228	14.67
60-69	.6198	6.26	.5054	26.60
70+ (Reference)				
SEX				
MALE	.3659	60.98	.4559	51.10
FEMALE	(Reference)		(Reference)	
MARITAL STATUS				
SINGLE	.1570	19.63	.4027	30.90
MARRIED	- .3977	-66.28	- .6987	-77.63
OTHER (Reference)				
COUNTRY OF BIRTH				
USA	.6411(*)	25.64	.2998	9.99
ENGLISH	.2719(*)	14.31	- .1296(*)	- 4.98
SCOTLAND	.6186(*)	24.74	.3234	8.51
ITALY	-.0308(*)	- .99	- .3346(*)	- 8.58
OFB	.9243(*)	84.03	.3174(*)	19.84
CB	.5638	62.64	.2791	23.26
MISSING (Reference)				
SES SCORE	-.0984	-14.06	- .4829	-25.42
SES*COUNTRY OF BIRTH				
USA	-.0387	- 1.67	- .2701	- 3.66
ENGLISH	-.0672	- 3.64	- .1386	- 2.48
SCOTLAND	-.1624	- 5.55	- .1791	- 2.04
ITALY	-.0535	- .91	.2637	3.42
OFB	.0439	2.91	- .1067	3.05
CB (Reference)				
L^2	9515.86		15530.23	
DF	178		154	

(1) In these and subsequent equations, only main effects and interactions involving country of birth with SES are shown in order to conserve space. Full equations are available on request.

(2) In this and subsequent equations, the SES*Country of Brith interaction effects are linear contrasts involving each immigrant group compared to the Canadian-born; hence the Canadian-born is the reference group for this term in the equations.

(3) The Z-statistics shown under the column "Z" are tests based on the null hypothesis that B=0. However, for our purposes, we are interested in contrasting immigrant groups with the Canadian-born to obtain a measure of relative risk. The symbols "(*)" next to the immigrant groups denote statistical significance at $P \leq .05$, based on the following test:

$Z = (B_i - B_{cs})/\mathrm{SQRT}\ (SE^2(B_i) + SE^2(B_{cs}) - 2\ COV(B_i, B_{cs}))$,

where B_i = parameter for a given immigrant group, B_{cs} = parameter for the Canadian-born; $SE^2(B)$ = the standard error squared for B; $COV(B_i, B_{cs})$ = the covariance for the parameters being contrasted.

The authors have predicted that immigrants would suffer increased rates of mortality from causes of death that are assumed to have a life stresses component to them. It is also anticipated that gains in SES will lower the mortality risk from such causes among foreigners. Based on the main effects analysis, and of the SES interactions, the authors can claim only qualified support of the life stresses thesis. Partial support for the prediction arises from two facts: the tendency in 1971, but not in 1981, for the immigrants (except Italians) to have higher suicide rates than the Canadian-born; and the consistently higher rates among the OFB over time with respect to all external causes of death. In all other instances, the native-born show higher risks than do immigrants, a pattern which goes against the life stresses idea. A further test of the hypothesis will be executed later.

TABLE 4a. LOG-RATE EQUATIONS FOR NEOPLASMS, CARDIOVASCULAR, CERTAIN DEGENERATIVE AND HOMICIDE MORTALITY, CANADA, 1971 AND 1981

	NEOPLASMS		CARDIOVASCULAR		CERTAIN DEGENERATIVE		HOMICIDE	
Term	1971	1981	1971	1981	1971	1981	1971	1981
λ	-8.2406	-8.6022	-7.9878	-8.4706	-10.0394	-9.4402	-12.1513	-11.7342
AGE								
15-29	-1.7753*	-1.6022*	-2.5457*	-2.2671*	-1.8069*	-1.5645*	1.3717*	.9942*
30-39	-.9050*	.8611*	-1.4552*	-1.2870*	-.9280*	-.5471*	.9414*	.8311*
40-49	.0504	.2738*	-.1190*	.0095	.2143*	.5390*	.6394*	.3808*
50-59	.6464*	.8235*	.6481*	.8153*	.5819*	.8104*	-.4999*	-.1727*
60-69	.9145*	.6919*	1.2927*	1.0540*	.8892*	.4238*	-.9422*	-.6516*
SEX								
MALE	.1791*	.1681*	.3581*	.4694*	.4111*	.3068*	.3709*	.2529*
MARITAL STATUS								
SINGLE	.1343*	.2674*	.1261*	.3161*	.1329*	.3300*	.3423*	.5468*
MARRIED	-.2898*	-.4965*	-.3992*	-.6451*	-.3263*	-.7948*	-.8769*	-.9380*
COUNTRY OF BIRTH								
USA	.5550*(*)	.2520*	.5815*	.1125*	.7757*	.3429*	.1634*(*)	.2517*
ENGLISH	.3981*(*)	-.1752*(*)	.3072*(*)	-.2057*(*)	-.1436*(*)	-.2973*(*)	.1136*(*)	-.6478*(*
SCOTLAND	.6493*(*)	.4039*(*)	.6653*(*)	.4543*(*)	.8025*(*)	.5435*	.6501*	.0910*(*
ITALY	.2753*(*)	-.0102 (*)	-.0046*(*)	-.3117*(*)	-.0171 (*)	-.3603*(*)	-.3041*(*)	.2124*
OFB	.9901*(*)	.3389*(*)	.8539*(*)	.3444*	1.0671*(*)	.4029*	1.5394*(*)	.8477*(*
CB	-.4653*	.1539*	.5644*	.3054*	.7173*	.2933*	.7053*	.2208*
SES SCORE	(-.1116)*	(-.2559)*	(-.0166)	(-.2864)*	(-.4289)*	(-.0398)*	(-.1888)*	
SES*COUNTRY OF BIRTH								
USA	..	-.1386	-.1304*	-.4035	.0313	-.7916	-.0829	..
ENGLISH	..	-.1453	.0082	.0284	-.1379	-1.0079	-.3524*	..
SCOTLAND	..	-.2131	-.1434*	-.3432	-.1979	-.5307	-.0569	..
ITALY	..	.1236	-.2261*	.1516	-.2504	.0000	-.8828	..
OFB	..	-.1757	.1206*	-.0594	.0966	-.3531	-.0986	..
CB (Reference)								
L^2	2857.7	4636.9	4536.8	8844.1	562.9	389.8	129.4	172.7
DF	188	154	178	154	178	154	179	177
FC	.0875	.1361	.10139	.13472	.10139	.13472	.10000	.10278

* $P \leq .05$.

(*) Refer to footnote 3 in table 3.

NOTE: Refer to Table 3 for reference categories of variables in these equations. This note applies also to Table 4b.

Only three equations for external causes of death contain interaction terms involving SES with country of birth: homicide in 1971, and other accidents and violence in 1971 and in 1981. Although the immigrants tend to show a general reduction in risk with gains in SES vis-à-vis the native-born, the Italians and OFB actually experience an increase in risk with regard to other accidents and violence in both periods.

TABLE 4b. LOG-RATE EQUATIONS FOR SUICIDE, MOTOR VEHICLE ACCIDENTS, OTHER ACCIDENTS-VIOLENCE AND RESIDUAL CAUSES OF DEATH, CANADA, 1971 AND 1981

	SUICIDE		MOTOR VEHICLE ACCIDENTS		OTHER ACCIDENTS-VIOLENCE		RESIDUAL	
Term	1971	1981	1971	1981	1971	1981	1971	1981
λ	-8.9531	-9.9940	-9.7651	-9.8479	-9.3836	-10.3945	-8.6524	-9.7646
AGE								
15-29	.3969*	.5842*	1.1219*	1.1044*	.2087*	-.0422	-1.1116*	-.9079*
30-39	.6078*	.4492*	.3657*	.2941*	.0875	-.1487	-.8855*	-.4869*
40-49	.7395*	.4557*	.0646*	.1175*	.1052	.1056	-.2897*	.1244*
50-59	.1463*	.1280*	-.0824*	-.3548*	-.1515*	-.0871	.2223*	.4791*
60-69	-.4531*	-.4821*	-.4779*	-.4331*	-.4122*	-.3745*	.6514*	.1930*
SEX								
MALE	.5604*	.5460*	.5375*	.4163*	.4891*	.4078*	.2689*	.4445*
MARITAL STATUS								
SINGLE	.2580*	.3805*	.1923*	.3943*	.3155*	.3354*	.3081*	.6083*
MARRIED	-.6021*	-.8509*	-.5321*	-.6199*	-.5191*	-.8932*	-.4981*	-.8353*
COUNTRY OF BIRTH								
USA	.8735*(*)	.2626*	.5349*	.2983*	.5679*	.3368*	.6214*	.2093*
ENGLISH	.4936*	-.0317*(*)	.1394*(*)	-.2878*(*)	.2823*(*)	-.0839*(*)	.1521*(*)	-.2133*(*)
SCOTLAND	.6176*	-.0041*(*)	.4490*	.0751 (*)	.5488*	.3803*	.5944*	.2630*
ITALY	-.4259*(*)	-.2399*(*)	.1306*(*)	-.0870 (*)	.0105 (*)	-.7824*(*)	-.1767*(*)	-.2082*(*)
OFB	1.1833*(*)	.6017*(*)	.9393*(*)	.5588*	.8831*(*)	.5229*	.9084*(*)	.3409*
CB	.3856*	.2968*	.5213*	.4161*	.5453*	.4060*	.6834*	.2791
SES SCORE	(-.2484)*	(---)	(-.0915)	(---)	(-.0053)	(-.0023)	(.0910)	(-.7783)
SES*COUNTRY OF BIRTH								
USA	--	--	--	--	-.0727	-.2328	.1006	--
ENGLISH	--	--	--	--	-.3746*	-.0266	-.0338	--
SCOTLAND	--	--	--	--	-.1875	-.8199	-.3697*	--
ITALY	--	--	--	--	.7848*	2.0540*	-.1911	--
OFB	--	--	--	--	.0079	.0878	-.0265	--
CB (Reference)								
L^2	425.5	796.4	763.5	1090.9	1090.5	1278.9	2733.0	2068.2
DF	194	172	194	172	196	166	183	159
FC	.00013	.10972	.07917	.10278	.09028	.11806	.09444	.12778

NOTE: FC means flattening constant; it is the adjustment used to handle empty cells and the problem of sparse data, as is the case with rare events such as death by cause. Instead of applying the customary constant of .500 to each cell, the FC used here considers the number of parameters fitted in a given model and the total number of cells in the data table to arrive at an average value assigned to each cell in the table. The formula for CF is: (P/2)/C, where P = the number of parameters in the fitted model, 2 is a constant, and C is the total number of cells in the table. Because of these "flattening" adjustments, the L^2 values in this table will always be lower than those reported in Table 2.

* $P \leq .05$.

(*) Refer to footnote 3 in table 3.

case of cancers, Italians in 1971 display increased odds in relation to the Canadian-born. Similarly, this study finds that the English also share positive coefficients for cardiovascular related mortality in both periods (also Italians in 1981).

Therefore, these and the previously mentioned findings suggest only a partial acceptance of the notion that gains in SES among immigrants lead to reduction in their risk of death from both external and chronic causes of infirmity. Also, the authors must reiterate that in seven equations in Tables 4A and 4B, the interaction terms of SES with nationality were found to be statistically unimportant (refer to Table 2 also). The clearest support for the hypothesis lies in connection with homicide in 1971, and, to a lesser extent, in the case of "certain degenerative" and neoplasms diseases, where the sign of effects in relation to the native-born is in the expected direction for virtually all groups.

Comparisons Incorporating Interaction Effects

Tables 5 and 6 present results incorporating all relevant interaction terms contained in the multivariate equations (full equations not shown, but available on request). In this part of the analysis, the native-born are used as the standard group for comparison purposes. The authors focus on the relative mortality risk (RMR) measure , computed as follows:

$$RMR_{ij} = \exp\left(\Sigma a_{ij}^{IG} - a_{ij}^{CB}\right),\ i=1,\ldots, I,\ j=1, \ldots, J$$

where a_{ij}^{IG} = parameter value for a given immigrant group for indexes *i* and *j*; a_{ij}^{CB} = parameter value for the Canadian-born for indexes *i* and *j*. The antilog of the difference is the RMR. A result of 1.000 means equality. A ratio below 1.000 indicates the foreign-born have lower odds than the native-born. A ratio above 1.000 means the opposite.

The top part of Table 5 pertains to single males in 1971 and 1981. The RMRs are computed by age, cause of death and nationality. Out of 200 possible comparisons in 1971 (excluding all causes of death), single male foreigners exceed the Canadian-born in mortality risk 108 times, or in 52% of the cases. In 1981 this differential is reduced to only 79 out of 200, or 40% of all contrasts. In 1971, immigrants suffered greater odds of death then the Canadian-born due to neoplasms. The highest relative risks are associated with the residual class of nativity and the Scottish. This situation improved considerably in 1981, especially for English single males, and for American, English and Italian married men.

With respect to cardiovascular mortality and "certain degenerative diseases," the immigrants and their native-born counterparts tend to share fairly similar risks in 1971, but foreigners do somewhat better in 1981. The Italians and the English share notably low odds in comparison to the remaining immigrant classes.

Concerning external causes of death, homicide has generally increased over time. For example, 10 out of 25 contrasts in 1971, and 14 in 1981, show RMRs over 1.000 for this cause of death among single men. OFB and Scottish single males stand out for their relatively high risks. With few exceptions, suicide has declined for all groups between 1971 and 1981. The lowest odds of self-inflicted death are among the Italians.

The largest discrepancy in favour of immigrants lies in connection with motor vehicle fatalities, other accidents/violence, and also in the case of residual causes. Out of 75 contrasts pertinent to these three categories of mortality risk, the foreign-born exceed the Canadian-born only 25 times in 1971, and only 18 times in 1981. It should be noted that OFB and U.S.A. immigrants generally tend to demonstrate ratios above 1.000 more frequently than any of the remaining immigrant groups.

The pattern of results for married males is generally similar to that described for single men. However, there is a tendency for the married to exhibit a higher risk vis-à-vis the standard group (native-born) than do the singles. As an example, examining the differences for single vs. married Italians concerning all causes of death, the married show greater risks. However, it is important to note that, irrespective of this fact, most of the measures are well below 1.000, which means that the married male immigrants tend to share reduced odds in comparison to native-born married males. Regarding all of the contrasts for married men, in 1971 immigrants exceed a ratio of 1.000 in 62% of the cases, but only 38% of the cases are above 1.000 in 1981.

The calculations for females demonstrate patterns that are not too dissimilar to those noted for males. That is, single immigrant females in 1971 show a slightly poorer mortality condition than do Canadian-born females (58% of ratios above 1.000), but in 1981 they improved considerably, with only 34% of all ratios being above 1.000. Married immigrant females do somewhat better than single immigrant males in that only 50% of their contrasts are above 1.000 in 1971, and only 29% in 1981. Thus, survival chances are slightly better for immigrant married females, and they share a larger improvement over time in comparison to male foreigners.

TABLE 5. RELATIVE MORTALITY RISK AMONG MALES BY CAUSE, IMMIGRANT GROUP, PERIOD, AGE AND MARITAL STATUS (CANADIAN-BORN AS STANDARD)

AGE, SEX, MARITAL STATUS AND IMMIGRANT GROUP	ALL CAUSES		NEOPLASMS		CARDIOVASCULAR		CERTAIN DEGENERATIVE DISEASES		HOMICIDE		SUICIDE		MOTOR VEHICLE ACCIDENTS		OTHER ACCIDENTS AND VIOLENCE		RESIDUAL	
	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981
SINGLE MALES																		
USA																		
15-29	1.001	.730	1.160	.859	.761	.364	.358	1.036	1.388	.811	1.482	.933	.931	.921	1.102	.892	1.128	.676
30-39	.978	.887	1.524	1.171	1.003	.649	1.400	1.100	.810	.845	1.959	.529	1.124	.692	.589	.662	1.081	.816
40-49	1.162	1.114	2.006	1.124	1.102	1.253	1.411	.603	.308	1.061	1.482	.455	.977	.655	.895	.831	1.099	.988
50-59	1.182	1.043	1.713	.987	1.199	.924	1.403	1.102	.147	.323	1.230	.738	1.209	.439	1.203	1.471	1.257	1.194
60-69	1.017	.959	1.494	1.087	1.023	.824	.991	.331	.344	.601	.950	.445	.817	1.189	1.097	1.010	1.192	1.498
ENGLISH																		
15-29	.608	.581	2.190	.431	1.032	.613	.269	.722	.301	.609	.965	.755	.711	.271	.538	.388	.538	.711
30-39	.437	.696	2.016	.877	.491	.843	.075	.348	.393	.535	.995	.513	.487	.257	.463	.379	.264	.341
40-49	.759	.655	2.681	.589	.706	.591	.374	.427	.300	.133	1.538	.442	.672	.352	.526	.366	.404	.347
50-59	.707	.911	2.462	.811	.735	.991	.461	.366	.524	.453	1.328	.475	.975	.204	.552	.398	.646	.773
60-69	.759	.755	2.614	.691	.878	1.001	.462	.131	1.267	.670	1.102	.784	.625	.413	.576	.438	.741	.691
SCOTLAND																		
15-29	.978	.810	3.193	1.395	1.072	1.688	1.904	1.746	1.538	1.355	1.373	.542	.553	.726	.603	1.275	.416	.694
30-39	.599	1.004	3.392	1.431	.510	1.131	.574	1.223	.957	1.245	.863	.868	.487	.690	.624	1.603	.711	.883
40-49	.940	1.098	3.545	1.466	.920	.821	1.254	1.503	1.479	1.452	1.613	.665	.538	.758	.769	1.210	.814	.759
50-59	.945	1.152	3.161	1.267	.908	1.178	1.141	.991	.378	1.546	1.197	.488	.767	.481	.966	.761	.885	.861
60-69	.988	.968	3.086	1.188	.877	.639	1.101	.733	1.159	1.110	1.644	1.711	.759	.801	1.173	.813	.917	.894
ITALY																		
15-29	.459	.626	2.841	2.536	.611	1.267	.721	.549	.157	1.340	.314	.572	.278	.389	1.617	.027	.379	1.413
30-39	.437	.532	2.063	1.687	.377	.395	.188	.167	.168	.931	.190	.426	.315	.369	.992	.035	.328	.869
40-49	.440	.682	1.425	.984	.429	.497	.202	.206	.165	.671	.496	.768	.559	.373	.676	.056	.216	.769
50-59	.427	.756	1.510	.925	.319	.651	.205	.419	.057	2.237	.282	.798	.656	.507	.953	.091	.296	.648
60-69	.624	1.111	1.851	1.084	.458	.927	.491	.362	.095	3.290	.846	1.059	.864	1.173	1.573	.185	.532	.823
OFB																		
15-29	1.424	.773	3.411	1.114	1.973	1.614	2.502	1.666	2.187	1.208	1.712	.942	1.241	.677	1.394	1.026	1.231	.957
30-39	1.301	1.005	3.667	1.463	1.051	.951	1.339	.962	1.941	1.509	1.581	.742	1.406	.644	1.266	.862	1.044	1.189
40-49	1.328	1.057	3.874	1.089	1.497	.978	1.284	.839	1.868	2.126	2.020	1.130	1.329	.774	1.206	1.005	.755	1.164
50-59	1.503	1.128	4.341	1.065	1.584	1.306	1.558	.782	1.833	1.446	1.728	1.325	1.561	.864	1.515	1.115	.876	1.266
60-69	1.452	1.064	4.918	.912	1.819	1.373	1.491	.585	2.468	1.991	2.049	1.833	1.227	1.004	1.513	1.265	1.008	1.234

AGE, SEX, MARITAL STATUS AND IMMIGRANT GROUP	ALL CAUSES		NEOPLASMS		CARDIOVASCULAR		CERTAIN DEGENERATIVE DISEASES		HOMICIDE		SUICIDE		MOTOR VEHICLE ACCIDENTS		OTHER ACCIDENTS AND VIOLENCE		RESIDUAL	
	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981
MARRIED FEMALES																		
USA																		
15-29	.978	.576	2.039	.683	.688	.274	.388	1.150	2.693	.731	1.595	1.578	.881	1.018	1.102	1.147	1.103	.494
30-39	.956	.711	2.681	.931	.908	.486	1.518	1.221	.432	.761	2.108	.895	1.065	.985	.589	.852	.967	.597
40-49	1.135	.879	3.525	.895	.997	.943	1.529	.671	.598	.961	1.606	.770	.926	.724	.895	1.069	.987	.723
50-59	1.155	.823	3.009	.786	1.085	.696	1.521	1.123	.284	.291	1.562	1.248	1.145	.485	1.203	1.890	1.129	.873
60-69	.994	.757	2.264	.866	.926	.620	1.074	.366	.668	.541	1.024	.753	.774	1.314	1.097	1.298	1.071	1.096
ENGLISH																		
15-29	.649	.438	2.274	.390	.990	.398	.401	.811	.119	.417	.661	.665	.616	.436	.538	.418	.622	.767
30-39	.467	.526	2.093	.794	.470	.547	.112	.391	.156	.367	.682	.452	.422	.414	.463	.408	.305	.368
40-49	.811	.495	2.782	.534	.677	.835	.556	.479	.119	.091	1.054	.389	.583	.567	.526	.395	.467	.375
50-59	.755	.688	2.555	.735	.706	.644	.684	.411	.208	.311	.910	.419	.845	.329	.552	.429	.740	.835
60-69	.810	.571	2.715	.625	.843	.650	.687	.147	.503	.459	.755	.691	.542	.665	.576	.473	.856	.746
SCOTLAND																		
15-29	1.057	.698	2.528	1.128	1.211	1.456	1.957	1.857	.675	1.206	1.274	.472	.791	.873	.603	1.278	.470	.781
30-39	.648	.865	3.385	1.157	.533	.974	.591	1.301	.411	1.108	.801	.757	.695	.830	.624	1.606	.791	.994
40-49	1.018	.946	3.595	1.186	.962	.708	1.289	1.601	.649	1.292	1.497	.581	.768	.912	.769	1.225	.920	.855
50-59	1.023	.992	3.290	1.024	.949	1.016	1.173	1.054	.166	1.376	1.111	.425	1.095	.577	.966	.763	1.000	.971
60-69	1.069	.833	4.023	.961	.916	.551	1.311	.779	.496	.981	1.526	1.482	1.084	.963	1.173	.814	1.037	.984
ITALY																		
15-29	.482	.472	3.508	1.735	.662	.923	.809	.885	.191	1.856	.263	.477	.271	.337	1.617	.049	.423	1.152
30-39	.458	.402	2.548	.639	.378	.288	.211	.269	.202	1.288	.158	.355	.307	.320	.992	.062	.366	.708
40-49	.462	.515	1.760	.673	.431	.362	.228	.332	.199	.928	.415	.641	.546	.323	.676	.099	.241	.626
50-59	.448	.571	1.866	.633	.321	.473	.231	.394	.069	3.111	.236	.666	.640	.439	.953	.161	.331	.528
60-69	.655	.838	2.286	.742	.458	.676	.551	.583	.114	4.561	.708	.884	.843	1.106	1.573	.328	.594	.671
OFB																		
15-29	1.206	.721	3.875	1.084	1.492	1.205	2.073	1.666	1.702	1.283	1.689	.847	1.338	.906	1.394	.899	1.386	.844
30-39	1.102	.936	3.706	1.424	.795	.711	1.109	.962	1.510	1.602	1.561	.668	1.517	.861	1.266	.755	1.145	1.048
40-49	1.124	.985	3.871	1.061	1.133	.730	1.064	.839	1.454	2.257	1.993	1.017	1.434	1.035	1.206	.881	.828	1.026
50-59	1.272	1.051	4.241	1.037	1.198	.975	1.291	.782	1.426	1.535	1.705	1.193	1.456	1.156	1.515	.977	.961	1.116
60-69	1.231	.991	3.905	.888	1.376	1.025	1.235	.585	1.920	2.113	2.021	1.651	1.324	1.343	1.513	1.100	1.105	1.089

TABLE 6. RELATIVE MORTALITY RISK AMONG MALES BY CAUSE, IMMIGRANT GROUP, PERIOD, AGE AND MARITAL STATUS (CANADIAN-BORN AS STANDARD)

AGE, SEX, MARITAL STATUS AND IMMIGRANT GROUP	ALL CAUSES		NEOPLASMS		CARDIOVASCULAR		CERTAIN DEGENERATIVE DISEASES		HOMICIDE		SUICIDE		MOTOR VEHICLE ACCIDENTS		OTHER ACCIDENTS AND VIOLENCE		RESIDUAL	
	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981
SINGLE FEMALES																		
USA																		
15-29	1.002	.643	1.147	.861	.702	.304	.361	.625	1.388	.725	1.482	1.073	.931	.932	1.102	.616	1.173	.640
30-39	.981	.781	1.507	1.173	.926	.539	1.412	.663	.810	.756	1.959	.608	1.124	.903	.589	.342	1.120	.773
40-49	1.163	.981	1.983	1.127	1.018	1.047	1.422	.364	.308	.947	1.482	.524	.977	.664	.895	.574	1.143	.936
50-59	1.183	.918	1.693	.991	1.107	.772	1.415	.611	.147	.289	1.230	.849	1.209	.444	1.203	1.015	1.308	1.131
60-69	1.019	.844	1.477	1.090	.945	.688	.999	.198	.344	.538	.950	.512	.817	.650	1.097	.697	1.240	1.419
ENGLISH																		
15-29	.583	.484	1.838	.391	.948	.500	.205	.428	.311	1.588	.965	1.062	.711	.390	.538	.587	.459	.590
30-39	.419	.582	1.692	.793	.445	.687	.057	.207	.393	1.396	.995	.722	.487	.371	.463	.573	.245	.284
40-49	.728	.547	2.248	.533	.648	.481	.285	.254	.300	.348	1.538	.622	.672	.508	.526	.555	.344	.289
50-59	.677	.760	2.065	.734	.675	.809	.351	.217	.524	1.182	1.328	.668	.975	.294	.552	.602	.551	.643
60-69	.727	.631	2.193	.624	.807	.816	.352	.078	1.267	1.748	1.102	1.103	.625	.595	.576	.664	.631	.575
SCOTLAND																		
15-29	1.026	.750	2.089	1.213	.958	1.511	1.298	1.221	1.538	1.642	1.373	.463	.553	.824	.603	1.296	.321	.763
30-39	.586	.930	2.873	1.244	.456	1.004	.391	.855	.957	1.510	.863	.743	.487	.784	.624	1.629	.540	.971
40-49	.921	1.017	2.974	1.275	.823	.729	.855	1.051	1.479	1.761	1.613	.569	.538	.861	.769	1.218	.629	.834
50-59	.924	1.067	2.722	1.102	.812	1.046	.778	.692	.378	1.873	1.197	.417	.767	.545	.966	.773	.683	.947
60-69	.966	.896	2.328	1.033	.784	.568	.751	.512	1.159	1.332	1.644	1.454	.759	.909	1.173	.826	.708	.961
ITALY																		
15-29	.417	.625	2.191	2.129	.597	1.306	.788	.989	.157	.958	.314	.354	.278	.441	1.617	.066	.315	.955
30-39	.397	.531	1.591	1.416	.341	.408	.206	.300	.168	.665	.190	.263	.315	.118	.992	.085	.272	.587
40-49	.411	.681	1.101	.826	.388	.512	.222	.372	.165	.479	.496	.475	.559	.422	.676	.135	.179	.521
50-59	.388	.755	1.165	.776	.288	.671	.225	.440	.057	1.598	.282	.493	.656	.573	.953	.220	.246	.438
60-69	.567	1.108	1.428	.910	.414	.956	.538	.652	.095	2.351	.846	.655	.864	1.326	1.573	.449	.441	.556
OFB																		
15-29	1.562	.701	4.852	1.028	2.303	1.453	2.795	1.535	2.187	1.539	1.712	1.292	1.241	.826	1.394	1.205	1.286	.905
30-39	1.427	.910	3.634	1.351	1.226	.856	1.496	.887	1.941	1.923	1.581	1.018	1.406	.785	1.266	1.012	1.091	1.125
40-49	1.456	.958	3.646	1.005	1.748	.881	1.435	.773	1.868	2.710	2.021	1.550	1.329	.944	1.206	1.180	.789	1.101
50-59	1.648	1.021	3.627	.983	1.849	1.176	1.741	.721	1.833	1.843	1.728	1.818	1.561	1.053	1.515	1.209	.915	1.201
60-69	1.593	.964	3.687	.842	2.123	1.237	1.665	.539	2.468	2.535	2.049	2.515	1.227	1.224	1.513	1.486	1.053	1.167

AGE, SEX, MARITAL STATUS AND IMMIGRANT GROUP	ALL CAUSES		NEOPLASMS		CARDIOVASCULAR		CERTAIN DEGENERATIVE DISEASES		HOMICIDE		SUICIDE		MOTOR VEHICLE ACCIDENTS		OTHER ACCIDENTS AND VIOLENCE		RESIDUAL	
	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981	1971	1981
MARRIED FEMALES																		
USA																		
15-29	.979	.507	2.015	.685	.635	.229	.391	.693	2.693	.652	1.482	1.816	.931	1.030	1.102	.792	1.053	.469
30-39	.958	.616	2.648	.934	.838	.406	1.531	.736	.432	.681	1.959	1.029	1.124	.997	.587	.440	1.006	.565
40-49	1.137	.773	3.485	.897	.921	.788	1.541	.404	.598	.853	1.482	.886	.977	.733	.895	.739	1.027	.685
50-59	1.157	.724	2.975	.788	1.002	.581	1.533	.677	.284	.261	1.230	1.436	1.209	.491	1.203	1.306	1.175	.828
60-69	.998	.666	2.955	.868	.855	.518	1.083	.221	.668	.484	.950	.867	.817	1.330	1.097	.897	1.114	1.038
ENGLISH																		
15-29	.622	.366	1.908	.353	.911	.325	.305	.481	.119	1.088	.965	.937	.711	.632	.538	.633	.531	.638
30-39	.447	.441	1.756	.719	.432	.446	.085	.232	.156	.957	.995	.636	.487	.597	.463	.618	.259	.306
40-49	.777	.414	2.334	.483	.622	.312	.424	.284	.119	.238	1.538	.548	.672	.817	.526	.598	.397	.312
50-59	.723	.575	2.144	.665	.648	.525	.522	.244	.208	.810	1.328	.589	.975	.474	.552	.649	.635	.694
60-69	.776	.477	2.278	.565	.775	.530	.524	.087	.503	1.198	1.102	.973	.625	.958	.576	.715	.729	.621
SCOTLAND																		
15-29	1.036	.646	2.091	.981	1.000	1.294	1.335	1.297	.675	1.461	1.373	.404	.553	.991	.603	1.298	.363	.859
30-39	.775	.801	2.875	1.010	1.278	.866	.402	.909	.421	1.343	.863	.648	.487	.943	.624	1.632	.611	1.093
40-49	.996	.876	2.974	1.031	.861	.629	.879	1.117	.649	1.566	1.613	.496	.538	1.036	.769	1.220	.711	.941
50-59	1.001	.919	2.722	.891	.848	.902	.811	.736	.166	1.667	1.197	.364	.767	.655	.966	.7775	.772	1.066
60-69	1.046	.772	3.328	.836	.819	.491	.771	.545	.496	1.185	1.644	1.268	.759	1.094	1.173	.827	.801	1.082
ITALY																		
15-29	.439	.472	2.707	.773	.598	.952	.886	1.594	.191	1.326	.314	.295	.278	.381	1.617	.118	.351	.779
30-39	.418	.401	1.966	.536	.341	.297	.231	.484	.202	.920	.190	.221	.315	.362	.992	.558	.304	.479
40-49	.421	.514	1.358	.565	.388	.373	.249	.599	.199	.663	.496	.396	.559	.366	.676	.578	.200	.424
50-59	.409	.570	1.439	.531	.289	.488	.253	.709	.069	2.214	.282	.412	.656	.497	.953	.616	.275	.357
60-69	.597	.837	1.764	.622	.414	.697	.604	1.051	.114	3.256	.846	.547	.864	1.149	1.573	.728	.493	.453
OFB																		
15-29	1.315	.653	3.646	1.000	1.742	1.085	2.298	1.535	1.702	1.635	1.712	1.163	1.241	1.104	1.394	1.056	1.410	.798
30-39	1.202	.848	2.532	1.314	.928	.639	1.231	.887	1.510	2.042	1.581	.917	1.406	1.051	1.266	.887	1.196	.991
40-49	1.384	.892	2.688	.978	1.322	.658	1.179	.773	1.454	2.877	2.021	1.395	1.329	1.262	1.206	1.034	.865	.977
50-59	1.388	.952	3.042	.957	1.399	.878	1.431	.721	1.426	1.956	1.728	1.637	1.561	1.409	1.515	1.147	1.004	1.056
60-69	1.229	.898	3.721	.819	1.606	.923	1.636	.539	1.921	2.692	2.049	2.264	1.227	1.637	1.513	1.302	1.154	1.029

Discussion

On the basis of the available literature, we developed the socioeconomic and life stresses hypotheses of mortality differentials among immigrants. It was discovered that the differentials among immigrant groups and between immigrants and the Canadian-born cannot be adequately summarized by nativity main effects alone. The models which provided a good fit to the data contained complex interaction terms involving nationality with other variables. From this experience, it can be said that summarizing differences in terms of standardized rates alone does not go far enough. It is impossible to speak of immigrant mortality differentials without considering interaction effects of age and sex net of their compositional components, and their interaction with marital status and country of birth.

Direct standardization of age and sex composition did not eliminate the mortality differentials. The authors also thought that a measure of SES, once entered into the analysis, would lead to a disappearance of variation across immigrant groups because of the presumed key role socioeconomic status plays in mortality inequality. This study found only limited support for the importance of this variable, as it did not explain much of the variation in death rates, and in a number of cases, SES failed to enter into the equations selected as good fitting models of the data.

It was thought that the effect of SES gain among immigrants in comparison to the native-born (the standard group) would lead to a lowering of their risk of dying from both general and cause-specific causes. In a general sense this idea was confirmed, but for the Italian immigrants, SES gains seem to increase their risk of death (but not enough to override their relatively low death rates overall – the lowest of the groups studied). A hypothesis worth pursuing in future research is that for low mortality groups, socioeconomic assimilation contributes to an increase in certain causes of death, possibly as a function of changes in lifestyle and diet. Only in the case of homicide do all groups in the analysis reduce their relative risks with gains in SES.

The most uniform pattern in this analysis is the higher relative risks of neoplasms in 1971 across all immigrant groups. This consistency suggests that foreigners may have been selected for higher susceptibility to develop cancers, and/or their new environment is somehow conducive to producing greater exposure to conditions responsible for carcinogenesis. Unfortunately, disentangling these two potential causes is an enormous task which would require more detailed data. At the very least, one would need information on the quality of environment prior to and after

migration, the age at immigration, and changes in lifestyle and health habits since relocation.[11]

The results concerning neoplasms for the 1971 period contrast with the findings by Kestenbaum (1986) in the United States, Brahimi (1980) in France, and Young (1987) in Australia, where overall cancer rates (studied during the late 1960s and early 1970s) tend to be lower among the immigrants. Perhaps it would be helpful in future research to disaggregate neoplasms into specific sites, as done by Lilienfeld *et al.* (1972), and by Marmot and colleagues (1984a). This approach would most certainly produce a more complete picture, but would also lead to greater complexities in interpretation, as in some sites mortality will be higher among immigrants, while in others it would be lower (see Marmot *et al.*, 1984a, for example).

Ten years later, in 1981, immigrants showed significant reductions in RMRs for cancer. The most notable gains are evident in connection with married females and married males born outside Canada.

Introducing data on the immigrants' countries of origin with regard to cancer mortality would help in the quest for answers, but would not contribute to definitive conclusions. Immigration is a selective process (Lee, 1966; Kasl and Berkman, 1985; Thomas, 1938). People who leave their country to settle in a new society differ significantly from those who remain. Regarding health, at the very least, immigrants must pass a medical screening examination before entry. This fact may explain why in recent decades foreigners in the United States and Canada show lower levels of general mortality than do the native-born.

Notwithstanding their relative superiority in survival, one needs better data to ascertain what happens to individuals years and decades after they have settled in their new land. They can be very healthy at the time of entry, only to deteriorate years later during the process of adjustment and assimilation. The situation with cancer may be an example of deterioration, but it is difficult to provide a direct test of this effect unless better data become available.[12]

Concerning the life stresses hypothesis, it was argued that all immigrants experience some degree of difficulty in their adjustment and adaptation to the host society, as their traditional old world attitudes and values often conflict with those of the host country. Many have to learn a new language, establish independent households and deal with many sources of

conflict and distress in their lives (such as unemployment, intergenerational conflict, providing for the family, establishing a new network of friends and coping with rapid change in their lives). These processes may cause extreme distress which could result in violent or accidental death. Based on the evidence in this study, only qualified confirmation for this hypothesis is provided.

In the case of death from suicide, motor vehicle accidents and violence, support for the thesis was found in connection with the residual immigrant class (OFB). It showed higher relative risks than the Canadian-born. However, it was also found that for the remaining immigrant groups (with some exceptions such as high rates of homicide among Italians in 1971, and high suicide risks for U.S.A. and Scottish immigrants in 1971) their relative odds are below persons born in Canada, a fact which is counter to the authors' prediction. It had been anticipated that mortality rates would be lowest among groups that are known to possess cohesive ethnic communities. Of the groups in this study, Italians in Canada fit this description, and they also share the lowest overall risk of death.

An important caveat that needs consideration in interpreting the results of this study has to do with the potential effects of selectivity bias due to group differences in return migration to their home countries. To the degree that such variability exists, this process would tend to "remove" the less healthy and the most stressed, and leave behind (in Canada) the more "healthy" individuals. This situation may explain why in general the immigrant groups in this analysis tend to share lower rates of death than do the native-born in certain causes of death (for example, external causes). This source of potential variability is virtually impossible to measure, as one would need information on the mortality of persons who have left Canada.

The most salient features of this analysis may be summarized as follows:

(1) Even after standardization for age and sex compositions and controls for SES, mortality differences are not eliminated;

(2) There have been significant declines in general mortality among all groups between 1971 and 1981;

(3) There has been general increases over time in homicide and deaths from "certain degenerative diseases" across virtually all immigrant classes;

(4) There has been a decline between 1971 and 1981 in cardiovascular mortality and cancer, but more so for the former cause;

(5) Deaths from suicide and accidents have declined over time;

(6) The lowest levels from overall and cause-specific mortality tend to be associated with the Italians and the English, while the highest odds from virtually all causes of death are typically connected with Other foreign-born and the native-born; and

(7) In 1971, all immigrant groups surpass the Canadian-born in the risk of death from cancers, while in 1981 significant improvements were noted, especially for married immigrants.

Two important methodological points need to be addressed before closing. Some of the differentials presented in Tables 5 and 6 depart considerably from 1.000 (the level of no difference). Persisting differentials may stem from numerous sources of heterogeneity (Vaupel, 1988; Vaupel *et al.*, 1979), both environmental and genetic in origin. Clearly, more variables need to be considered in the equations before a full explanation of immigrant mortality differences can be given. It is possible, of course, to introduce a heterogeneity factor as a residual term in the equations, but the statistical gain in doing this would be offset by the difficulty in specifying what are the varied sources of heterogeneity, and perhaps even more challenging would be to identify how they interact among themselves, and with the observed variables.[13]

The authors tried to assess and control sources of errors and problems in the data employed in this analysis. An important step in this direction was to explicitly control for the potential confounding effects of cases for which information on country of birth was missing on the death certificate. Such cases as a separate category of nationality were included in the multivariate equations, thus serving as a control variable. Unfortunately, the authors have no control on the extent to which coroners may misclassify the nationality of decedents. Misclassification of country of birth could cause artificial inflation or deflation of computed rates for any given immigrant group. Secondly, incorrect reporting of nationality and undercount in the census would have similar effects. There is have little reason to suspect that such problems are pervasive in connection with the country of birth variable in the census, as undercoverage for this variable is relatively small (Sharma et. al., 1989).

country of birth variable in the census, as undercoverage for this variable is relatively small (Sharma et. al., 1989).

This study poses a number of interesting challenges for future research. How can we better understand the mortality experience of immigrants in host nations as a process that is independent of persons' experiences before migration? What is the role of life stresses associated with the migration experience in health, morbidity and mortality among immigrants? How do social support mechanisms in the receiving society serve to buffer the "shocks", or stresses associated with immigrant adaptation? These questions may help to solve the puzzle as to why certain immigrant groups seem to do better than others in terms of survival. More theoretical effort in this line of inquiry is needed. Finally, on a methodological note, it would be important to somehow retrieve the missing information on country of birth and replicate this analysis in order to ascertain whether results would depart significantly from those reported once complete information is used.

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Notes

1. Of course, one needs to make a distinction between the broad categories of native-born/foreign-born and more refined classifications that include specific nationality groups. According to Kmet (1979), results do not always fall into a uniform and consistent pattern once specific nationality groups are examined and more than one cause of death is introduced in the analysis. For example, Kestenbaum (1986) concerned himself with the broad classification, native-born vs. foreign-born. On the other hand, others such as Lilienfeld *et al.*, (1972) dealt with 16 immigrant groups. Not surprisingly, the results are not always as clear-cut as those reported by Kestenbaum. As a case in point, Lilienfeld and associates found that overall cancer deaths among males for 1959-61 were higher in 15

to show very low rates in some cases (for example, melanoma) and elevated risks (such as cancers of the digestive system) in others.

2. Kitagawa and Hauser (1973) did examine the relationship between socioeconomic status and mortality, but their focus was on the general American population. In their analysis of nativity, they did not introduce controls for economic measures (such as education and occupation). A study which examines social class differences in immigrant mortality is that of Marmot and associates (1984a) in England and Wales. The authors employed graphical and tabular analyses, but not in a multivariate context such as that adopted in this study. An inverse social class gradient was found.

3. Factor analysis with principle components extraction and varimax rotation was used to derive the SES index in the analysis. A one factor solution was extracted, which the authors define as SES. The amount of variance explained by this factor varied with cause of death, between 65 and 96%. It is important to realize that the SES scores assigned to the mortality cell counts in the data set do not represent individual level data. The information was taken from the Public Use Sample Tapes, but was aggregated in accordance with the authors' definition of variables; that is, the socioeconomic indicators had to be aggregated on the basis of the age-sex-marital status-period-nationality specific breakdowns. Thus it would not be prudent to draw individual level inferences from the data, as the focus is on the immigrant group. Another reason for exercising caution pertains to the fact that by appending census data to the decedents, the authors are implicitly assuming that the census population's SES characteristics are the same as those of the decedents. Of course, it is impossible to verify the veracity of this assumption given that official death records in Canada do not contain any background socioeconomic information on the individual. One possible way to check for the extent of correspondence between census and mortality information would be to use the record linkage method applied by Kitagawa and Hauser (1973). Unfortunately, this option is beyond the scope of the present analysis.

4. Unfortunately, it is not possible to classify decedents on the basis of their country of birth, ethnicity, and the ethnic origin and place of birth of parents simultaneously. The parental variables are incompletely coded on the death records, and since 1981, the census no longer records parents' country of birth, making it impossible to obtain appropriate denominators for the computation of mortality risk

on the basis of decedents' parental ethnicity and birthplace. In fact, the ethnic variable on the death certificate has been discontinued since 1973. The situation respecting country of birth is problematic as well. During the early 1950s, the information for this variable was virtually complete. During the early sixties approximately three percent of the records in the mortality data base (MDB) contained decedents' country of birth. The situation for this variable since 1971 has improved considerably, but it is far from perfect. As documented in this study, we saw that in 1980-81, 24.4 percent of all records in the MDB did not include the decedent's country of birth.

5. During the initial stages of data compilation, the authors we considered disaggregating this category into smaller identifiable groups with relatively recent and established immigrant histories. However, it became evident that doing so would not be feasible nor practical. Given that they had decided on 11 causes of death and five covariates (age, sex, marital status, nativity, year) to define the structure of their data file, the more subgroups the authors added to the data set, the larger the number of empty cells. Moreover, for many specific subgroups, the necessary population counts (denominators) could not be obtained, as they are classified under "Other" nationality in the census and could not be disaggregated. The authors had considered including Germany as a country of birth (a large immigrant group in Canada) in this study, but the Public Use Census Tapes do not differentiate the two Germanies, so the idea was abandoned.

6. Regarding the large number of cases with "missing" country of birth in 1980-81, when this paper was presented to the 1990 Annual Meetings of the Canadian Population Society in Victoria, British Columbia, two demographers indicated that perhaps most of the "missing" cases could be retrieved if one petitions the individual provincial vital statistics bureaus. Certainly, this is not a small task, but it is encouraging for future work. However, obtaining this information may not be easy.

7. The authors tested to see whether the "missing" cases are uniformly distributed across categories of the variables in the data set (for example, age, sex, marital status, period) by fitting logit models to the dependent variable, "missing" vs. "not missing". The results indicated that the model of independent main effect should be rejected and that more complex models (with several higher order interaction terms) more adequately describe the distribution of missing cases, and therefore, one could not assume uniform distribution of missing cases.

That is, one cannot assume, that the missing cases were missing at random (Little and Rubin, 1987).

8. The purpose of the procedure indicated in the text is to derive denominators (exposures) for the death records that do not contain decedents' country of birth. A point worth considering is that such cases possess complete information on all other relevant variables, namely age, sex, marital status, cause of death, and so on. This attempt is, therefore, to incorporate all this information into the log-rate multivariate analysis. Removing the cases with missing country of birth would mean a significant loss of important information. It is important to note that since the dependent variable being modeled is a rate, the death counts must have corresponding exposures.

   Since it is impossible to identify from the Canadian censuses the exposures that correspond to the deaths with missing information on nationality, some procedure would have to be developed to derive denominators for this special subset of the mortality data file, such that the "missing" could be incorporated into the analysis as a separate category of the country of birth variable. This method would allow for the computation of meaningful contrasts in the net risk of mortality across nationality groups.

   The adopted method, consists of inputing an arbitrary exposure for the cases with missing country of birth, derived as follows:

   $E_{ijkl} = \Sigma\ (P_{ijkl}-D_{ijkl})$, $i=1, ...I$, $j=1, ...,J$, $k=1, ...,K$, $l=1, ...,L$,

   where:

   E_{ijkl} = estimated exposures for missing nationality by age, sex and marital status,

   P_{ijkl} = population counts for the known nationality groups by age, sex and marital status,

   D_{ijkl} = death counts by nationality group by age, sex and marital status.

   The effect of this method on the death rate for the "missing" nationality is obvious: it will deflate it. This fact is not a problem here since the aim is not in modelling the absolute death rate, but to obtain parameter estimates of relative mortality risk for each migrant group in relation to the Canadian-born once the effect of "missing" and other relevant variables are statistically controlled. Irrespective of the fact that the log-linear parameters for "missing" nationality will always be

of a small magnitude, differences in parameters across groups in relation to the Canadian-born will be meaningful.

9. SPSSx Loglinear was used to fit the log-rate models reported in this study. The λ term is not explicitly obtained with this subroutine and must be calculated manually once an equation has been computed. For example, $\lambda = \log (D_{ij}^*/Eij) - \Sigma(ax_i + ax_j + ax_{ij})$, where D_{ij}^* = the expected deaths under a fitted model, E_{ij} are the exposures, and $(ax_i + ax_j + ax_{ij})$ are parameter effects for a baseline combination of categories corresponding to variables in the fitted model.

10. In total, 244 models had to be fitted in order to arrive at the results shown in Table 2.

11. To the authors' knowledge, the only country that records age at immigration on the death record is Australia (see Young, 1987; Burwill *et al.*, 1973; and McMichael *et al.*, 1980).

12. Many studies in the literature compare standardized mortality ratios for immigrants, their country of origin, and their host nation. A dominant idea behind these comparisons is that they may provide an indirect test of genetic predisposition to certain diseases. For example, when the migrants and their origin population have equal or comparable mortality levels with regard to a certain cause (for example, lymphoma) the presumed mechanism may be thought to be a genetic predisposition. Another objective in making these kinds of analyses is to gain some sense of whether immigrants are selected for either low or high predispositions to certain diseases. The most frequent patterns encountered in the epidemiologic literature are: (1) an intermediate level of risk for immigrants in relation to origin and destination countries; and (2) immigrants showing the lowest risk in relation to both origin and destination societies (Kasl and Berkman, 1985). A common interpretation in the literature is that immigrants are a select group in both personal and health characteristics and carry their survival superiority with them to their new environment.

    Unfortunately, interpretations based on these kinds of contrasts are of limited utility. The data typically employed cannot tell, for example, whether the lower rates of immigrants are actually a function of genetic selection, selectivity in health habits and life styles, or possibly, due to improvements in the lives of migrants in their new society. Furthermore, it is not possible to determine nor disentangle possible interaction effects of genetic selection, behavioural sources of

selectivity, and the effects of change in environments. Nor is it possible to ascertain with any degree of certainty whether the lower death rates of foreigners may be a consequence of assimilation with respect to such things as diet, exercise and health habits characteristic of their host society.

A similar word of caution is applicable whenever immigrants demonstrate rates above both their origin and destination countries. Such a difference may be a reflection of negative selection in health and/or possible deterioration in health due to the migration process itself. At the very least, it is risky to affirm that comparison of origin, migrants and destination populations, provides adequate proof of genetic and/or environmental effects on mortality unless more data are introduced in the analysis, such as length of residence in the host nation, health status before and after migration, change in, lifestyle habits, and numerous other behavioural indicators that cannot be extracted from death records.

13. This is an important point which would require more rigorous methodological attention. The biggest challenge would be to model heterogeneity and how its unobserved sources interact with observed variables in the model. Existing techniques for modelling heterogeneity tend to assume independence for the sake of statistical parsimony (see Trussell, 1989, for a critique of this area of research).

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