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Association between socioeconomic status and cancer incidence in Toronto, Ontario: possible confounding of cancer mortality by incidence and survival

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Objective: To observe the association between socioeconomic status (SES) and cancer incidence in a cohort of Canadians.

Design: Cases of primary malignant cancer (83 666) that arose in metropolitan Toronto, Ont., from 1986 to 1993 were ascertained by the Ontario Cancer Registry and linked by residence at the time of diagnosis to a census-based measure of SES. Socioeconomic quintile areas were then compared by cancer incidence.

Results: Significant associations between SES and cancer incidence in the hypothesized direction — greater incidence in low-income areas — were observed for 15 of 23 cancer sites.

Conclusions: These findings, together with the recently observed consistent pattern of significant associations between SES and cancer survival in the United States and the equally consistent pattern of nonsignificant associations in Canada, support the notion that differences in cancer incidence alone explain the observed cancer mortality differentials by SES in Canada. The cancer mortality differential by SES observed in the United States is probably a function of differences in both incidence and length of survival, whereas in Canada such mortality differentials are more likely to be merely a function of differences in incidence by SES. This pattern of associations primarily implicates differences in the 2 health care systems; specifically, the more egalitarian access to preventive, investigative and therapeutic services available in the single-payer Canadian system.

A consistent inverse association has been observed between cancer mortality and socioeconomic status (SES) across many common cancer sites, epidemiologic methods and countries (Canada, the United States, various European nations, Australia and New Zealand).[1–11] A large Canadian study, for example, found mortality disadvantage with low SES for 14 of 20 common cancers.[11] At the same time, length of survival seems to be essentially unassociated with SES in Canada. Among adults with cancer followed until 1994 in metropolitan Toronto, Ont., SES was not significantly associated with 5-year survival for 12 of 15 common cancers;[12] similarly, nonsignificant associations between SES and survival have been observed for 8 of 10 cancers in Hamilton and London, Ont., in samples followed for more than 1 to 10 years.[13,14] Perhaps not surprising given their systemic similarities such as single-payer health care, this Canadian pattern of significant associations between SES and cancer mortality and slightly significant or nonsignificant associations between SES and survival is similar to that observed in a study from The Netherlands.[15] That study's authors suggested that The Netherlands' cancer mortality differential is probably more a function of differences in cancer incidence

Significance?

Social class–cancer mortality gradients have been consistently observed throughout the developed world; the reasons for this are not necessarily the same in each country. This study strongly suggests that such cancer mortality inequity is predominantly accounted for by greater cancer occurrence among the poor in Canada, whereas in the United States it is probably a function both of their greater risk of getting cancer as well as their greater risk of dying from it. Incidence and survival measure distinct phenomena. Who ultimately gets cancer is an aggregate function of tumour-initiating and -progressing factors, typically acting over years. Cancer survival, on the other hand, is probably a function of more proximate factors acting during the months immediately before and after diagnosis. This study points toward the need to continue policies that support healthy lifestyle changes in both Canada and the United States.

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by SES, which is a plausible hypothesis that they did not directly test.

Reviews of more than 40 studies about cancer incidence have found significant disadvantage with low SES in the United States and 10 other developed nations, and again this pattern has been consistently observed across more than 10 common cancer sites, as well as a variety of epidemiologic methods (e.g., individual and ecological SES measures).[16,17] However, no Canadian study was included in these reviews. Numerous occupational epidemiologic investigations of cancer incidence have been accomplished in Canada, but these have tended to focus on environmental exposures (e.g., herbicides, electromagnetic fields, occupational dust) rather than on the social class component of various occupations.[18–26] One case–control study, originally designed to detect an association between residential radon and lung cancer incidence in Winnipeg, found a significant inverse association between education and cancer incidence; the odds of lung cancer occurrence was 2-fold greater among people not completing high school.[27] We are unaware of a single study that has rigorously planned a comparison of the incident cancer experience of various social classes in Canada. The present study does so, and we believe that it not only increases our understanding of the social epidemiology of cancer in Canada but also aids in the interpretation of patterns of cancer incidence, survival and mortality by SES worldwide.

Methods

The Ontario Cancer Registry provided access to data on the 23 most common cancer sites. Among adults (25 years of age and older) in metropolitan Toronto (noninstitutionalized population of 3.5 million in 1991, 2.6 million adults), 83 666 cases of primary malignant cancer arose from 1986 to 1993 (Table 1).[28] Definition of the incidence study cohort was constrained by the following: 1986 was the first year in which the registry coded most cases by residence (mandated hospital reporting initiated), and the registry's date of last follow-up was Dec. 31, 1993. The Ontario Cancer Registry has been estimated to ascertain more than 95% of the cancers that arise in Ontario, a rate that compares favourably with, for example, the United States' Surveillance, Epidemiology and End Results (SEER) program registration rate.[29,30] Other indices of the registry's validity are also near-exact replicates of SEER's: 89.2% microscopically confirmed and 1.6% enumerated on the basis of death certificates only.

As is the case with nearly all cancer registries, the Ontario Cancer Registry does not code any socioeconomic variables. Cancer cases were thus joined with census tracts to socioeconomic data collected by the 1991 population census of Canada.[28] Such geographic coding was based on each person's residence at the time of diagnosis and was accomplished for 94% of the cases. For our analysis we focused on the metropolitan Toronto area because 1 of every 7 Canadian residents (1 of every 3 in Ontario) lives there, and the meaningful residential coding rates at the level of census tracts or smaller for cases arising in other, predominantly rural, areas of Ontario are very low (generally less than 75%, and in some instances less than 50%).[31–33] In rural areas, postal codes may be represented by local delivery units that often cover very large areas and are comprised of many enumeration areas. Thus, valid socioeconomic mapping from postal to census geography is more difficult, if not currently impossible, in rural areas. This fact, in addition to the external validity gained through the use of a greater metropolitan Toronto sample, is our rationale for restricting the sample to an urban area.

Statistics Canada's low-income criterion was used to

Table 1: Cancer cases among adults in metropolitan Toronto, Ontario, 1986–1993

Cancer site/type	ICD-9 codes	No. of incident cancer cases	
		Women	Men
Oral	140–9	898	1 674
Esophagus	150	301	553
Stomach	151	1 100	1 742
Colon	153	4 255	4 202
Rectum	154	1 563	2 088
Liver	155	288	669
Pancreas	157	1 209	1 162
Larynx	161	140	781
Lung, bronchus	162	4 644	8 572
Melanomas	172	976	1 126
Breast	174	13 227	
Cervix uteri (invasive)	180	1 576	
Corpus uteri	182	2 486	
Ovary	183	2 061	
Prostate	185		9 349
Bladder	188	982	2 800
Kidney	189	967	1 539
Brain, central nervous system	191–2	840	964
Thyroid	193	1 211	362
Hodgkin's disease	201	210	365
Non-Hodgkin's lymphomas	200, 202	1 608	2 025
Multiple myeloma	203	518	511
Leukemias	204–8	963	1 159
Total		42 023	41 643

Note: ICD-9 = International Classification of Diseases, 9th revision.

measure SES. It is conceptually similar to the US Bureau of the Census' poverty threshold. Both are based on annual household income from all sources adjusted for household size.[28,34] The Canadian low-income cut-off is a more liberal criterion; it is approximately equal to 200% of the US poverty threshold — a measure that, in another context (New York State), has been found to be highly associated with cancer incidence.[35] This criterion was used to divide the cohort into low (23% or more of the neighborhood's households below the low-income cut-off) through high (less than 7% of the households below the criterion) income area quintiles of 147 census tracts each. Directly age-adjusted incidence rates were then compared, and 95% confidence intervals (CI) around the low- versus high-income cancer rate ratios (RR) were calculated using the Mantel–Haenszel χ^2 test.[36,37]

Results

Significant associations between SES and cancer incidence in the hypothesized direction — greater incidence in low-income areas — were observed among women and men for 15 of the 23 cancer sites studied (Table 2, first section, sites displayed in descending order of commonness in the low-income quintile). In fact, 26 of the 41 comparisons (18 sites in both sexes and 5 in one sex) indicated such a significant inverse relation. Also, consistent with what has been found in

Table 2: Association between socioeconomic status (low income criterion) and cancer incidence in metropolitan Toronto, 1986–1993

	Women				Men			
Cancer site/type	No. of cases*	Rate†	RR‡	95% CI§	No. of cases*	Rate†	RR‡	95% CI§
INVERSE ASSOCIATION								
Lung, bronchus								
High income¶	555	35.43	1.00**		1013	40.89	1.00	
Low income¶	908	44.72	1.26	1.18–1.34	1921	106.02	2.59	2.27–2.96
Colon								
High income	556	36.54	1.00		602	38.05	1.00	
Low Income	738	36.03	0.99	0.97–1.01	770	42.06	1.11	1.02–1.20
Bladder								
High income	139	9.19	1.00		412	26.26	1.00	
Low income	202	9.78	1.06	1.01–1.11	521	28.60	1.09	1.00–1.19
Non-Hodgkin's lymphomas								
High income	218	13.77	1.00		296	18.24	1.00	
Low income	303	14.93	1.08	1.02–1.15	402	22.07	1.21	1.05–1.40
Stomach								
High income	132	8.73	1.00		214	13.71	1.00	
Low income	243	11.77	1.35	1.19–1.53	431	23.62	1.72	1.49–1.99
Rectum								
High income	192	12.56	1.00		286	17.71	1.00	
Low income	268	13.12	1.04	1.01–1.07	403	22.10	1.25	1.08–1.44
Oral								
High income	100	6.27	1.00		156	9.62	1.00	
Low income	168	8.28	1.32	1.12–1.56	364	20.34	2.11	1.75–2.54
Kidney								
High income	135	8.47	1.00		236	14.49	1.00	
Low income	189	9.29	1.10	1.00–1.21	309	16.94	1.17	1.02–1.35
Pancreas								
High income	140	9.47	1.00		134	8.48	1.00	
Low income	219	10.60	1.12	1.04–1.20	234	12.97	1.53	1.25–1.87
Leukemias								
High income	120	7.96	1.00		150	9.50	1.00	
Low income	153	7.48	0.94	0.84–1.05	228	12.47	1.31	1.09–1.57
Cervix uteri								
High income	178	10.28	1.00					
Low income	309	15.75	1.53	1.29–1.82				
Liver								
High income	23	1.50	1.00		68	4.24	1.00	
Low income	69	3.40	2.27	1.56–3.31	161	8.90	2.10	1.60–2.76
Larynx								
High income	15	0.90	1.00		78	4.85	1.00	
Low income	31	1.52	1.69	1.01–2.84	173	9.67	1.99	1.53–2.58

other developed countries, some of the largest effects (from 50% to more than 2-fold greater risk in poor areas) seemed to be for sites of cancers thought to be caused, at least in part, by behavioural and environmental factors that are typically more prevalent among poorer people (e.g., cigarette smoking, alcohol consumption, other dietary and occupational risk factors, sexual promiscuity): lung, stomach, oral, pancreas, cervix uteri, liver, larynx and esophagus.

Evidence in support of the Ontario Cancer Registry's discriminate validity was provided by observation of the opposite trend among the "cancers of affluence": breast cancer, prostate cancer and melanomas. Consistent with the findings from other developed countries such as the United States, these cancers were found to be directly associated with SES; that is, their incidence was greater in high-income areas. They are thought to be caused at least in part by behavioural and environmental factors that may typically be more prevalent among wealthier people (e.g., high-fat and low-fibre diets, sedentary lifestyles and accompanying obesity, and sunlight exposure associated with leisure pursuits). Finally, of the 8 nonsignificant comparisons involving the 5 cancer sites displayed at the bottom of Table 2, 7 of the rate ratios were in the predicted direction of an inverse association between SES and cancer incidence, and 1 of these (ovary) would have been deemed significant if a more liberal 90% confidence interval had been used.

Table 2: Continued

Cancer site/type	Women				Men			
	No. of cases*	Rate†	RR‡	95% CI§	No. of cases*	Rate†	RR‡	95% CI§
Esophagus								
High income	30	1.91	1.00		57	3.59	1.00	
Low income	71	3.47	1.82	1.30–2.55	133	7.45	2.08	1.54–2.81
Multiple myeloma								
High income	60	3.93	1.00		90	5.83	1.00	
Low income	95	4.67	1.19	1.01–1.40	88	5.19	0.89	0.68–1.16
DIRECT ASSOCIATION								
Breast								
High income	2148	127.65	1.00					
Low income	2250	113.23	0.89	0.80–0.99				
Prostate								
High income					1443	94.98	1.00	
Low income					1546	82.88	0.87	0.75–1.02
Melanomas								
High income	190	11.00	1.00		228	13.67	1.00	
Low income	123	6.18	0.56	0.44–0.71	162	8.94	0.65	0.54–0.80
NO STATISTICALLY SIGNIFICANT ASSOCIATION								
Corpus uteri								
High income	358	22.16	1.00					
Low income	453	22.52	1.02	0.99–1.05				
Ovary								
High income	286	17.41	1.00					
Low income	363	18.16	1.05	0.99–1.11				
Thyroid								
High income	187	10.41	1.00		50	2.94	1.00	
Low income	244	12.38	1.19	0.96–1.47	67	3.66	1.24	0.81–1.89
Brain, central nervous system								
High income	118	7.25	1.00		133	8.07	1.00	
Low income	133	6.64	0.92	0.77–1.09	165	9.07	1.12	0.95–1.32
Hodgkin's disease								
High income	25	1.39	1.00		53	3.30	1.00	
Low income	32	1.59	1.14	0.68–1.91	70	3.81	1.15	0.86–1.54

*Number of incident cancer cases.
†Incidence rate per 100 000 population; directly age-adjusted using the total population of metropolitan Toronto in 1991 by sex across the following age groups: 25–44, 45–54, 55–64, 65–74 and ≥75 years.[28]
‡Standardized incidence rate ratio (rate of lowest income quintile / rate of highest income quintile).
§CI = confidence intervals; derived using Mantel–Haenszel χ^2 test.[36,37]
¶Based on Statistics Canada's 1991 low-income criterion: low income = lowest areal income quintile (highest proportional representation of low-income households [≥23%]; 147 census tracts; 247 360 women and 232 830 men 25 years of age or older); high income = highest areal income quintile (lowest proportional representation of low-income households [<7%]; 147 census tracts; 221 665 women and 209 365 men 25 years of age or older).
**Baseline.

Discussion

We studied the effect of SES on the incidence of the 23 most common types of cancer among adult women and men in metropolitan Toronto from 1986 to 1993. Cancer incidence was significantly (95% CI) greater among people residing in lower SES areas for most of the cancers studied: lung, colon, bladder, non-Hodgkin's lymphomas, stomach, rectum, oral, kidney, pancreas, leukemias, cervix uteri, liver, larynx, esophagus and multiple myeloma. This consistent pattern of indirect associations between SES and cancer incidence across divergent cancers is clearly consistent with what has been found in other developed nations including the United States. This pattern is also consistent with the previously observed indirect associations between SES and cancer mortality for most cancers in Canada.[11] These findings, together with the recently observed consistent pattern of significant associations between SES and cancer survival in the United States (lower survival among the poor for 12 of 15 sites) and the equally consistent nonsignificant associations in Canada (no association between SES and cancer survival for 12 of 15 sites),[12] support the notion that differences in cancer incidence alone explain the observed cancer mortality differentials by SES in Canada. In fact, these 3 studies of SES and cancer in Canada allow for the strikingly consistent inference that, of the 12 cancer sites for which there was an inverse association between SES and mortality (and that were included in all 3 studies), 9 were similarly related by incidence, but not survival: lung, colon (men only), bladder (men only), stomach, rectum, oral, kidney, pancreas and cervix uteri.

The present study replicates and extends previous inferences in this field. Along with other studies, it suggests that cancer incidence, survival and mortality are all inversely associated with SES in the United States, but in Canada only incidence and mortality are so associated with SES. Stated another way, the socioeconomic cancer mortality differential observed in the United States is probably a function of differences in both incidence and survival, whereas in Canada such mortality differentials are more likely to be merely a function of differences in incidence by SES. We believe that this pattern of associations primarily implicates differences in the 2 health care systems; specifically, the more egalitarian access to preventive, investigative and therapeutic services available in the single-payer Canadian system, compared with the United States' insurance-driven or multi-payer system that does not guarantee minimal access to such services.

Potential ecological fallacy

It is important to note that the SES variable in our study was census-based and therefore ecological with respect to income measurement. Our goal was not, however, to assign individual cases a specific income based on their census tract of residence as a proxy, but rather to assign them to 1 of 5 broad SES classifications: residence in relatively low- through high-income areas. The information bias that may intrude because the socioeconomic exposure variable is measured ecologically is clearly far less potent when aggregating cancer cases into socioeconomic quintiles, as we did, than if such ecological measures are analytically used as more direct proxies for each individual's SES.[38–40] Furthermore, the magnitude of misclassification error that may affect this analysis seems to compare favourably with that routinely encountered in related epidemiologic domains and is also likely to be nondifferential.[41–43] The ecological fallacy notwithstanding, we believe it is important to simply know that where people with cancer live, specifically among those who live in areas of low SES concentration, is highly associated with how long these people live after diagnosis in the United States, but not in Canada. Our study's contextual inferences are thus most relevant to understanding community-level phenomena such as systemic environmental factors that may differ between the 2 countries.[35,44,45] The different health care systems is one such cogent factor that parsimoniously fits with our findings.

A related ecological study ought to be mentioned here because it refutes our central theory. Mackillop and colleagues[46] have observed significant direct associations between SES and cancer survival for 9 of 13 types of cancer across the entire province of Ontario. Although their socioeconomic measure was primarily based on enumeration areas, which in terms of population counts are typically much smaller than census tracts, approximately one-third of the cases in their study had to be linked instead to census subdivisions because enumeration areas are not used by Statistics Canada in all areas of the province (e.g., outlying rural areas).

Mackillop and colleagues' findings certainly seem to clash with our previous census tract-based observation of nonsignificant associations between SES and survival for 12 of 15 common cancers.[12] Closer appraisal, however, suggests to us that these 2 studies are measuring conceptually different ecological constructs, and the findings may in fact be consistent with each other. For example, our study of census tract areas in metropolitan Toronto assessed relatively small neighborhood enclaves, which in most cases are smaller than

one square kilometer and typically cluster around 0.5 km^2; however, the ecological units used in their provincial study were typically 100-fold and often 500 to more than 1000 times larger. We think it is likely that such larger area units are measuring the construct of regional service endowment (primary care and oncological [radiographic, surgical] resources related to cancer care). Clearly the provincial findings are profoundly important and have implications for the way health care resources are regionally distributed. However, we believe that within metropolitan areas, where most Canadians live, the extant data still strongly support the notion that socioeconomic differentials in cancer mortality in Canada are predominantly a function of differences in incidence and not in survival.

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