2011

Effects of socioeconomic status on colon cancer treatment accessibility and survival in Toronto, Ontario, and San Francisco, California, 1996-2006

Kevin M. Gorey
University of Windsor

Isaac N. Luginaah
University of Western Ontario

Emma Bartfay
University of Ontario Institute of Technology

Karen Y. Fung
University of Windsor

Eric J. Holowaty
University of Toronto

Effects of Socioeconomic Status on Colon Cancer Treatment Accessibility and Survival in Toronto, Ontario, and San Francisco, California, 1996–2006

Kevin M. Gorey, PhD, MSW, Isaac N. Luginaah, PhD, Emma Bartfay, PhD, Karen Y. Fung, PhD, Eric J. Holowaty, MD, Frances C. Wright, MD, Caroline Hamm, MD, and Sindu M. Kanjeekal, MD

Objectives. We examined the differential effects of socioeconomic status on colon cancer care and survival in Toronto, Ontario, Canada, and San Francisco, California.

Methods. We analyzed registry data for colon cancer patients from Ontario (n=930) and California (n=1014), diagnosed between 1996 and 2000 and followed until 2006, on stage, surgery, adjuvant chemotherapy, and survival. We obtained socioeconomic data for individuals' residences from population censuses.

Results. Income was directly associated with lymph node evaluation, chemotherapy, and survival in San Francisco but not in Toronto. High-income persons had better survival rates in San Francisco than in Toronto. After adjustment for stage, survival was better for low-income residents of Toronto than for those of San Francisco. Middle- to low-income patients were more likely to receive indicated chemotherapy in Toronto than in San Francisco.

Conclusions. Socioeconomic factors appear to mediate colon cancer care in urban areas of the United States but not in Canada. Improvements are needed in screening, diagnostic investigations, and treatment access among low-income Americans. (*Am J Public Health.* 2011;101:112–119. doi:10.2105/AJPH.2009.173112)

A study of cancer survival in low-income areas of Toronto, Ontario, and Detroit, Michigan, during the 1980s found advantages among Canadians for common cancers.[1] The Toronto survival advantage was replicated for breast cancer across diverse low-income Canadian and US contexts through the 1990s.[2] Studies of that era, however, were not able to account for differences in stage of disease at diagnosis. More recent studies that accounted for breast cancer stage again found Canadian advantages.[3–6] In the United States, women with breast cancer who lived in low-income areas waited longer for surgery and adjuvant radiation therapy and were less likely to receive radiation therapy or to survive. Similar disparities between high- and low-income women with breast cancer did not exist in Canada; thus low-income Canadians fared better across most breast cancer care indices than their US counterparts. More inclusive health insurance in Canada was advanced as the most plausible explanation.

Colon cancer care may be an even more important health care performance indicator. The second most frequent cause of cancer death in North America, its prognosis can be excellent with early diagnosis and treatment.[7,8] For several reasons, colon cancer seems particularly instructive for Canada–US cancer care comparisons. First, research on income and colon cancer survival has found moderate to strong inverse associations in the United States but only modest to null associations in Canada.[1,9–13] Second, colon cancer screening is important, but implementation is at an early stage in both countries.[14,15] Third, effective chemotherapies proliferated during the 1990s for stage III colon cancer and more recently for stage II disease.[16–18] Fourth, screening, diagnosis, and treatment of colon cancer are more accessible to persons with higher socioeconomic status in the United States.[18–22] Colon cancer screening is more prevalent among higher-income persons in Canada,[23] but no previous study has examined associations of socioeconomic status with colon cancer treatment in that country.

Because past studies have not observed associations between socioeconomic status and breast cancer treatment in Canada,[3–5] we hypothesized that we would also find no significant correlation. Previous comparisons of colon cancer survival in Canada and the United States showed a significant advantage for Canadians only for low-income and not for middle- or high-income patients.[1,9,24] These international studies of colon cancer survival, however, did not account for differences in stage at the time of diagnosis between countries, as ours did. Because of Canada's broad health insurance coverage, we expected to find an interaction between income and country for survival. We hypothesized that a direct income–survival gradient would exist in an urban California cohort but not in an urban Ontario cohort and that low-income persons in Ontario would have a survival advantage over those in urban California.

METHODS

We obtained registry data for randomly selected, staged colon cancer cases diagnosed between 1996 and 2000 (*International Classification of Diseases, Ninth Revision* code 153[25]) and followed until 2006 from Toronto, Ontario (n=930), and San Francisco, CA (n=1014). We selected these 2 cities with comparable populations (greater than 5 million residents) because both had extensive health care services, to control for cancer care service availability.[26,27] Cohorts were powered to detect modest 5-year survival rate differences of 10% across 3 socioeconomic strata within and between places (2-tailed $\alpha=0.05$; power$_{1-\beta}=0.80$).[28]

Sampling frames were the Ontario and California cancer registries, which validly monitor the most populous Canadian province and US state.

Both ascertain nearly all colon cancer cases (98% or more) with nearly perfect rates of microscopic confirmation and nearly nil rates of death certificate identification.[29–32] Toronto and San Francisco oversamples were drawn (1050 each) to account for unstaged cases and other missing data. Only 41 of the Toronto charts were lost to retrospective review, and these did not differ significantly on key study variables from the remaining 1009 that were retrieved. Insufficient information was available to stage 79 (7.8%) Toronto cases and 36 (3.4%) San Francisco cases; these were excluded. This represented a significant between-place difference ($\chi^2_{1,2059}$= 18.82; $P<.05$); however, the prevalence of missing data was not significantly associated with other key independent and dependent variables. Therefore, sample losses were unlikely to have confounded our study's hypothesized relationships.

Variables

For the Ontario sample, we abstracted from hospital and physicians' office patient charts the same study variables that were routinely coded by the California registry.[33–35] These were stage of disease at diagnosis (according to American Joint Committee on Cancer guidelines),[34] receipt of initial surgery, number of regional lymph nodes evaluated, receipt of adjuvant chemotherapy, and waiting times from diagnosis to surgery and chemotherapy. Defining characteristics of the cancer stages were stage I (invasion into bowel wall muscle), stage II (invasion through bowel wall muscle), stage III (metastasized to at least 1 regional lymph node), and stage IV (distally metastasized). Stage 0 or in situ tumors were not sampled. When cancer stage was not reported, it was derived from Surveillance, Epidemiology, and End Results extent of disease variables. Agreements were high among 3 chart abstractors, who were trained by an experienced cancer registrar. Interrater assessments of 150 randomly sampled health records found κ coefficients ranging from 0.88 to 0.96 across study variables.

Similar thresholds for economic deprivation are used by Statistics Canada (low income) and the US Bureau of the Census (poverty). Both are based on annual household income adjusted for household size, but the Canadian low-income cutoff is approximately 140% of the US poverty threshold.[36] The Canadian measure approximates near-poverty status, a measure of demonstrated predictive validity in the United States.[24,37] Our previous research suggested that these 2 measures, although not identical, would provide valid comparisons of relatively low- to high-income urban neighborhoods in the 2 countries.[2,4]

We first linked colon cancer patients in Toronto and San Francisco to, respectively, Canadian (2001) and US (2000) censuses by their residential census tract at diagnosis.[26,27] Next, to maximize predictive validity and to match our income measures with those commonly used in cancer disparities research, we delineated the following San Francisco neighborhoods: high income (less than 5% of households poor; 40% of patients), middle income (5%–9% poor; 35% of patients), and low income (10% or more poor; 25% of patients).[2,4,38,39] We then delineated proportionally similar Toronto neighborhoods according to Statistics Canada's low-income criterion. Purchasing power–adjusted distributions of our sample's income tertiles in Toronto and San Francisco are displayed in Table 1.[40,41] Annual household incomes were nearly identical in each metropolitan area's respective low-income neighborhoods. Affluence was slightly more prevalent in San Francisco.

Analyses

We used maximum likelihood logistic or binomial regression models to estimate the associations of demographic, prognostic, and cancer care factors with binary 5-year (survived or not) all-cause colon cancer survival.[42,43] Missing data were imputed from full models. We estimated odds ratios (ORs) and confidence intervals (CIs) from regression statistics. After we entered all main effects into the model, we tested the hypothesized 2-way income-by-place interaction and explored all 3-way interactions (income by place by another factor).[42,44] We then described significant interactions by comparing within-place colon cancer survival rates across income strata and between-place survival rates within income strata. We directly adjusted all rates by age and stage, with our combined Toronto–San Francisco sample as the standard. We used rate ratios (RRs) for within- and between-place comparisons, with 95% CIs derived from the Mantel–Haenszel χ^2 test.[45,46]

RESULTS

Descriptive profiles of the Toronto and San Francisco colon cancer patients in our sample are displayed in Table 2. They were nearly identical demographically, their unadjusted receipt of surgical and chemotherapeutic interventions was strikingly similar, and their overall 5-year survival experience did not differ significantly. Treatment waiting times of 60 or more days were more prevalent in Toronto, but median waiting times for surgery (Toronto, 5 days; San Francisco, 4 days) and adjuvant chemotherapy (Toronto, 46 days; San Francisco, 47 days) did not differ significantly. Patients in San Francisco were more likely to be diagnosed with localized, stage I disease and to have more lymph nodes evaluated during staging. In no instance was the prevalence of missing data significantly associated with income or survival. Therefore, it is unlikely that any of the modest between-place differences in

TABLE 1—Prevalence of Low-Income or Poor Households in Colon Cancer Patients' Neighborhoods: Toronto, ON, 2001, and San Francisco, CA, 2000

	Toronto, Prevalance of Low-Income Households		San Francisco, Prevalence of Households Living in Poverty	
Neighborhood Income	Range (Median)	Income,[a] $	Range (Median)	Income,[a] $
High	2.60–14.40 (9.50)	78 400	0.20–4.99 (3.20)	85 000
Middle	14.50–25.70 (19.50)	55 650	5.00–9.99 (6.60)	59 725
Low	25.80–76.50 (33.70)	41 550	10.00–49.75 (15.70)	40 850

Note. Neighborhood income derived from Statistics Canada[26] and US Census[27] data.
[a]Census tract median annual household income in US dollars.

TABLE 2—Demographic and Clinical Characteristics of Colon Cancer Patients: Toronto, ON, and San Francisco, CA, 1996–2006

	Toronto, No. (%)	San Francisco, No. (%)
Age at diagnosis, y		
25–59	206 (22.2)	219 (21.6)
60–69	242 (26.0)	231 (22.8)
70–79	272 (29.2)	312 (30.8)
≥80	210 (22.6)	252 (24.9)
Women	466 (50.1)	505 (49.8)
Stage at diagnosis[a]		
I	227** (24.4)	337** (33.2)
II	215 (23.1)	229 (22.6)
III	270** (29.0)	227** (22.4)
IV	218 (23.4)	221 (21.8)
Received surgery	842 (90.5)	936 (92.3)
Waiting time from diagnosis to surgery, d		
<14	610** (73.8)	609** (67.4)
14–29	125** (15.1)	205** (22.7)
30–59	58 (7.0)	69 (7.6)
≥60	33** (4.0)	20** (2.2)
Missing data	16** (1.9)	33** (3.5)
Received chemotherapy	266 (28.6)	316 (31.7)
Missing data for receipt of chemotherapy	0** (0.0)	16** (1.6)
Wait time for chemotherapy		
Had chemotherapy before surgery	24 (11.3)	43 (14.0)
<30 d after surgery	32** (15.1)	77** (25.1)
30–59 d after surgery	86 (40.6)	133 (43.3)
≥60 d after surgery	70** (33.0)	54** (17.6)
Missing data	54** (20.3)	33** (10.7)
No. of regional lymph nodes examined		
<6	304** (41.1)	274** (30.3)
6–11	282** (38.1)	312** (34.6)
12–15	68** (9.2)	151** (16.7)
≥16	86** (11.6)	166** (18.4)
Missing data	102** (12.1)	33** (3.5)
Survived 5 y from diagnosis	463 (49.8)	516 (50.9)

[a]American Joint Committee on Cancer staging.[34]
**$P<.05$ for between-country difference (χ^2 test).

missing data substantially confounded our analyses.

Income-by-Place Interactions

The full logistic regression model for 5-year colon cancer survival, including all main effects and significant interactions, is displayed in Table 3. As hypothesized, we found a strong income-by-place interaction (OR=2.57; 95% CI=1.47, 4.49). Among low-income patients, Toronto residents had a significant survival advantage (OR=2.51; 95% CI=1.52, 4.15; interaction stratum not shown), but for middle- and high-income patients, survival in the 2 cities did not differ significantly. We also identified 3-way income-by-place interactions for stage and for lymph node evaluation (Table 4).

These findings replicated several well-known associations reported in other studies. For example, younger age, female gender, earlier stage of disease at diagnosis, evaluation of more than 15 regional lymph nodes, and receipt of surgery and chemotherapy were all associated with better survival in this and previous studies. After we accounted for such demographic and clinical factors, the main effects of income and place were both null.

Depiction of Two- and Three-Way Interactions

Significant interactions are depicted in Table 4. For the entire sample, survival was associated with income in San Francisco but not in Toronto. The 5-year survival rate was significantly lower in San Francisco's low-income than in its high-income neighborhoods (RR=0.84; 95% CI=0.72, 0.98). Among high-income patients, Toronto residents had lower survival rates than did San Francisco residents (RR=0.86; 95% CI=0.75, 0.98).

We added successive sample restrictions to estimate the probable relative effects of earlier diagnosis among high-income San Franciscans and of more accessible treatment among low-income Torontonians. First, when we analyzed only patients with nonlocalized, stage II through stage IV colon cancer, the income–survival gradient remained for San Francisco, but the US survival advantage among residents of high-income neighborhoods was eliminated. We still found no significant correlation for Toronto. Next, we analyzed survival only for the most treatable colon cancers, stages II and III. The income–survival gradient remained for San Francisco and was still not significant for Toronto, but among low-income patients, the survival advantage shifted to Canadians (RR=1.23; 95% CI=0.98, 1.54).

In an analysis of stage II colon cancer only, where recent innovations may provide clinicians and care managers with the most treatment discretion, we found evidence of an even larger Toronto survival advantage in relatively low-income neighborhoods (RR=1.30; 95% CI=0.98, 1.73). When we controlled for receipt of chemotherapy (RR=1.05; 95% CI=0.81, 1.36), our results strongly suggested that the observed Toronto advantage was explained by better access to adjuvant treatment (data not shown). We observed no significant within- or between-place differences for stage III colon cancer

TABLE 3—Logistic Regression Results for Main Effects and Interactions of Neighborhood Income and Place: Toronto, ON, and San Francisco, CA, 1996–2006

Predictor Variables	OR (95% CI)
Significant main effects	
Age at diagnosis	0.62 (0.56, 0.69)
Stage at diagnosis[a]	0.20 (0.16, 0.24)
Gender (female advantaged)	1.32 (1.06, 1.64)
Received surgery	3.40 (1.89, 6.12)
>15 regional lymph nodes examined	1.57 (1.16, 2.13)
Received chemotherapy	1.53 (1.04, 2.25)
Significant interaction effects	
Neighborhood income by place	2.57 (1.47, 4.49)
Neighborhood income by place by stage at diagnosis	0.67 (0.52, 0.88)
Neighborhood income by place by ≥15 nodes examined	0.20 (0.05, 0.72)
Nonsignificant main effects	
Place	0.94 (0.68, 1.29)
Neighborhood income	0.94 (0.73, 1.02)
Waited ≥30 d after diagnosis for surgery	0.84 (0.59, 1.21)
Waited ≥60 d after surgery for chemotherapy	0.90 (0.75, 1.06)

Note. CI = confidence interval; OR = odds ratio. Total sample from both cities was n = 1944.
[a]American Joint Committee on Cancer staging.[34]

(data not shown). Rates for patient refusal of chemotherapy were similar (less than 5%) in the 2 cities.

We also analyzed interactions of income, place, and lymph node evaluation (Table 4). A probable proxy for thoroughness of colon cancer care (effective staging and treatment), lymph node evaluation depends on the expertise of both surgeons and pathologists.[47–49] Patients with surgically resected stage II or III colon cancer are the most likely to benefit from valid staging and adjuvant chemotherapies; in this group, lower income was associated with less thorough lymph node evaluation in San Francisco but not in Toronto. Among high-income patients, however, lymph node evaluation was more thorough in San Francisco than in Toronto. That is, staging for Torontonians was much less likely to be based on the evaluation of more than 15 regional lymph nodes (RR=0.51; 95% CI=0.34, 0.77). Such thorough lymph node evaluations were associated with better 5-year survival in both Toronto and San Francisco. However, after modest income adjustment that restricted the analysis to patients who resided in middle- or low-income neighborhoods, the lymph node evaluation–survival association was maintained in Toronto (RR=1.40; 95% CI=1.06, 1.85), but completely eliminated in San Francisco. This suggests that income substantially mediates this colon cancer care–survival relationship in San Francisco but not in Toronto. It is also likely that the Toronto survival advantage among patients who experienced more thorough lymph node evaluation (RR=1.46; 95% CI=1.08, 1.97) is attributable to their better access to indicated chemotherapies. The age-adjusted rate of chemotherapy receipt among middle- to low-income Toronto patients with stage II or III colon cancer (57.3%) was much higher than that of their counterparts in San Francisco (34.3%; RR=1.67; 95% CI=1.06, 2.64).

DISCUSSION

To our knowledge, ours is the first report of the effect of socioeconomic status on colon cancer survival in similar Canadian and US cities that accounted for disease stage. We found strong support for our income-by-country interaction hypothesis. In within-place comparisons, colon cancer survival in San Francisco was significantly worse among people living in lower-income neighborhoods. Low-income patients in San Francisco also experienced less thorough lymph node evaluations and had less access to adjuvant chemotherapies. We found no associations between socioeconomic status and colon cancer care or survival in Toronto.

The survival advantage among high-income persons in San Francisco was probably attributable to earlier diagnosis. The survival advantage among low-income people in Toronto, particularly those with the most treatable, stage II or III colon cancer, was very likely a result of more thorough lymph node evaluations and better access to indicated chemotherapies. Of interest to both policymakers and clinicians is our finding that after these interaction effects were accounted for, the main effects of income and place were no longer significant. Socioeconomic factors appear to be associated with colon cancer care in both countries but in different ways: high-income US patients have an advantage in prediagnostic care and perhaps in screening, and low-income Canadians have an advantage in postdiagnostic care and possibly in staging and treatment.

Our finding that colon cancer care–survival relationships were mediated by income in the US cohort but not in the Canadian cohort likely illustrates the effects of inadequate health insurance coverage along with its corollaries of inaccessible primary care and cancer care among America's near poor to poor.[2,50] Low-income Canadians with colon cancer, although their risks and vulnerabilities are similar to those of low-income Americans, are relatively less deprived in at least 1 critical characteristic. Their access to medically necessary care is guaranteed through a single-payer system. Americans receive health care in a multitiered, multipayer system, and some have much less access to care than others. Our findings are consistent with those of many US studies that observed strong relationships between low income, absent or inadequate health insurance, and less prevalent screening for colon cancer, relatively later diagnosis, lack of treatment access, and lower survival.[14,51–57] Systemic health care issues, rather than personal, biological, or cultural factors, are the most plausible explanations for our findings because we accounted for a key biomarker—disease stage at diagnosis—and refusal rates for indicated

TABLE 4—Effects of Interactions of Socioeconomic Status and Place on Colon Cancer Care and 5-Year Survival: Toronto, ON, and San Francisco, CA, 1996–2006

	Toronto		San Francisco		
	No.[a] (Rate)	RR[b] (95% CI)	No.[a] (Rate)	RR[b] (95% CI)	Toronto and San Francisco RR (95% CI)
SES by place on 5-year survival					
All cases[c]					
High income (Ref)	372 (0.474)	1.00	409 (0.552)	1.00	0.86** (0.75, 0.98)
Middle income	327 (0.558)	1.18 (1.02, 1.37)	358 (0.502)	0.91 (0.80, 1.03)	1.11 (0.97, 1.26)
Low income	231 (0.440)	0.93 (0.79, 1.10)	247 (0.463)	0.84** (0.72, 0.98)	0.95 (0.79, 1.15)
SES by place and stage on 5-year survival					
Stage II to IV					
High income (Ref)	285 (0.393)	1.00	262 (0.427)	1.00	0.92 (0.75, 1.12)
Middle income	229 (0.425)	1.08 (0.87, 1.34)	245 (0.414)	0.97 (0.82, 1.15)	1.03 (0.81, 1.30)
Low income	189 (0.399)	1.02 (0.84, 1.24)	179 (0.334)	0.78** (0.61, 1.00)	1.19 (0.92, 1.53)
Stage II and III					
High income (Ref)	194 (0.546)	1.00	183 (0.563)	1.00	0.97 (0.80, 1.17)
Middle income	159 (0.586)	1.07 (0.89, 1.28)	161 (0.582)	1.03 (0.89, 1.20)	1.01 (0.80, 1.26)
Low income	132 (0.559)	1.02 (0.87, 1.19)	112 (0.454)	0.81** (0.65, 1.00)	1.23* (0.98, 1.54)
Stage II					
High income (Ref)	77 (0.628)	1.00	96 (0.636)	1.00	0.99 (0.87, 1.12)
Middle income	84 (0.708)	1.13 (0.93, 1.37)	84 (0.653)	1.03 (0.84, 1.26)	1.08 (0.90, 1.30)
Low income	54 (0.711)	1.13 (0.87, 1.46)	49 (0.545)	0.86 (0.67, 2.10)	1.30* (0.98, 1.73)
SES by place on examination of >15 regional lymph nodes					
Stage II and III					
High income (Ref)	191 (0.138)	1.00	178 (0.272)	1.00	0.51** (0.34, 0.77)
Middle income	158 (0.099)	0.72 (0.38, 1.38)	158 (0.165)	0.61** (0.40, 0.92)	0.60* (0.33, 1.10)
Low income	129 (0.190)	1.38 (0.87, 2.19)	110 (0.184)	0.68* (0.44, 1.06)	1.03 (0.80, 1.32)
Examination of >15 regional lymph nodes by place on 5-year survival					
<16 nodes (Ref)	414 (0.544)	1.00	349 (0.529)	1.00	1.03 (0.88, 1.21)
>15 nodes	64 (0.688)	1.26** (1.02, 1.55)	97 (0.614)	1.16* (0.97, 1.38)	1.12 (0.90, 1.39)
Only low- and middle-income neighborhoods					
<16 nodes (Ref)	249 (0.555)	1.00	221 (0.534)	1.00	1.04 (0.88, 1.23)
>15 nodes	38 (0.777)	1.40** (1.06, 1.85)	47 (0.534)	1.00 (0.89, 1.13)	1.46** (1.08, 1.97)

Note. CI = confidence interval; NA = not applicable; RR = standardized rate ratio; SES = socioeconomic status. Except as noted, we directly adjusted all rates for age and stage by our sample's combined Toronto–San Francisco population of cases as the standard (age categories: 25–59, 60–69, 70–79, and 80 years or older; stage categories were: I, II, III, and IV). The interaction pattern was similar for men and women (i.e., SES by place by gender and SES by place by stage by gender interactions were not significant), so rates were not adjusted for gender. Confidence intervals were derived from the Mantel-Haenszel χ^2 test.

[a]Number of incident breast cancer cases.

[b]A rate ratio of 1.00 was the within-place baseline.

[c]Not stage adjusted.

*P = .10; **P < 0.5.

treatments were similar among our Canadian and American cohorts.

Our findings are also consistent with very low rates of colon cancer screening during the mid-to-late 1990s. For example, fewer than 1 in 5 Ontario residents aged 50 to 59 years were screened for colon cancer by any method during that era.[58] Cancer Care Ontario, the agency responsible for the province's cancer services, instituted a colon cancer screening program in 2007.[59] It provides funding to screen all average-risk adults aged 50 years and older with the fecal occult blood test every 2 years and to screen those at increased risk with colonoscopy. Earlier colon cancer diagnoses are expected to become more common in Ontario in the wake of this program, and the relative disadvantage of relatively affluent Canadians compared with similarly affluent Americans is expected to disappear.

Limitations

Our use of ecological measures might suggest an alternate explanation for our results. Perhaps the racial/ethnic composition of low-income neighborhoods, rather than their concentration of low-income households,

accounted for the between-country colon cancer survival differences we observed. We believe this is unlikely for several reasons. First, recent US studies of colon cancer treatment and survival have consistently found that socioeconomic differences explained most racial-group differences.[60–63] Second, although we were not able to adjust for this factor directly because the Ontario registry does not code race/ethnicity, we were able to replicate key findings by comparing the subsample of non-Hispanic White patients in San Francisco with the entire racially and ethnically diverse Toronto sample. In what was perhaps the most provocative between-place comparison—5-year survival of low-income patients with stage II or III colon cancer—our original analysis revealed a Toronto advantage, and this advantage remained even when we excluded all members of any racial/ethnic minority group that composed more than half of the original low-income San Francisco sample.

Because our socioeconomic measures were census tract aggregates that did not directly capture individual income–colon cancer care relationships, our findings might be seen as ecological fallacies. We believe, however, that census tract characteristics can serve as proxies of community-level phenomena and national health care access differences. Another question is whether the low-income measures were adequately comparable in San Francisco and Ontario. They were not compositionally identical: our income thresholds were derived from the US Census Bureau's definition of poverty and Statistics Canada's of low income. No study has directly compared the construct or predictive validities of such ecological measures in Canada and the United States, but their validity has been shown in the United States,[38,39,43,64] and national censuses in both countries provided estimates of median census tract or neighborhood-level income in urban areas. In these data, household incomes typically differed by less than US$1000 in the low-income neighborhoods of San Francisco and Toronto. This indicates their similar aggregate lack of purchasing power, which is probably also the best contextual definition of our central ecological measure. Although they are probably similarly challenged to purchase life's necessities, residents of such neighborhoods differ contextually in 1 important way: Canadians in low-income neighborhoods appear to enjoy higher-quality health care than do similarly poor Americans.

Another possible limitation of our study was incomplete information on outpatient treatments among North American cancer registries.[65,66] Such data are more difficult to collect than inpatient data. However, the California registry has been shown to be most complete for chemotherapy data (84%) in San Francisco.[67] In addition, analyses of hospital-based surgery, lymph node evaluation, and survival were unlikely to have been affected,[68] and missing chemotherapy data were not prevalent and did not practically differ between our Toronto and San Francisco samples.

We focused on all-cause, rather than cancer-specific, survival. Cancer was the underlying cause of death among the vast majority of patients with stage II and III colon cancer in our Toronto and San Francisco samples. The underlying cause of many deaths not coded as cancer mortality can be directly associated with lack of treatment or with cancer treatment complications.[69] Although length of survival is highly accurate in cancer registries, the underlying cause of death is not.[29] Finally, although substantial death certificate error was a likely limitation,[70] our low-income, between-place, all-cause survival comparison was closely replicated with a cancer-specific comparison.

Conclusions

Affluent colon cancer patients received earlier diagnoses in San Francisco than in Toronto, and low-income Canadians experienced better investigation and treatment than did their American counterparts. Socioeconomic factors in particular appear to influence colon cancer care in urban America. Policies are needed to improve cancer screening, diagnostic investigations, and treatment access among low-income Americans. ■

About the Authors

At the time of the study, Kevin M. Gorey was with the School of Social Work and Karen Y. Fung was with the Department of Mathematics and Statistics, University of Windsor, Ontario, Canada. Isaac N. Luginaah was with the Department of Geography, University of Western Ontario, London. Emma Bartfay was with the Faculty of Health Sciences, University of Ontario Institute of Technology, Oshawa. Eric J. Holowaty was with Population Studies and Surveillance, Cancer Care Ontario, Toronto. Frances C. Wright was with the Department of Surgery and the Department of Health Policy, Management and Evaluation, University of Toronto, Ontario, Canada. Caroline Hamm and Sindu M. Kanjeekal were with the Department of Medical Oncology, Windsor Regional Cancer Center, Ontario, Canada.

Correspondence should be sent to Kevin Gorey, School of Social Work, University of Windsor, 401 Sunset Ave, Windsor, Ontario, N9B 3P4 (e-mail: gorey@uwindsor.ca). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints/Eprints" link.

This article was accepted October 23, 2009.

Contributors

K.M. Gorey conceptualized and supervised the study and led the writing. K.Y. Fung led the analysis. All authors assisted with study design, data analysis, and interpretation and writing.

Acknowledgments

This research was supported in part by the Canadian Breast Cancer Research Alliance (Canadian Institutes of Health grant 67161), the Canadian Cancer Society (National Cancer Institute of Canada grant 016160), the Social Sciences and Humanities Research Council of Canada (grant 410-2002-0173), and an Assumption University research chair and Canadian Institutes of Health investigator award to K.M. Gorey.

We gratefully acknowledge the administrative and logistical assistance of William E. Wright, chief, Cancer Surveillance Section of the California Department of Health Services at the time this study was initiated. We also gratefully acknowledge the research and technical assistance of Carole Herbert, Cancer Care Ontario; Leah Archambault, Natalie Herbert, Dylan Herbert, Nancy Richter, and Madhan Balagurusamy; University of Windsor; and Mark Allen California Cancer Registry.

Human Participant Protection

This study was reviewed and cleared by the University of Windsor's research ethics committee and the Ontario Cancer Research Network's research ethics board.

References

1. Gorey KM, Holowaty EJ, Fehringer G, et al. An international comparison of cancer survival: Toronto, Ontario, and Detroit, Michigan, metropolitan areas. *Am J Public Health.* 1997;87(7):1156–1163.

2. Gorey KM. Breast cancer survival in Canada and the USA: meta-analytic evidence of a Canadian advantage in low-income areas. *Int J Epidemiol.* 2009;38(6):1543–1551.

3. Gorey KM, Fung KY, Luginaah IN, Holowaty EJ, Hamm C. Income and long-term breast cancer survival: comparisons of vulnerable urban places in Ontario and California. *Breast J.* 2010;16(4):416–419.

4. Gorey KM, Luginaah IN, Hamm C, Fung KY, Holowaty EJ. Breast cancer care in Canada and the United States: ecological comparisons of extremely impoverished and affluent urban neighborhoods. *Health Place.* 2010;16(1):156–163.

5. Gorey KM, Luginaah IN, Holowaty EJ, Fung KY, Hamm C. Wait times for surgical and adjuvant

radiation treatment of breast cancer in Canada and the United States: greater socioeconomic inequity in America. *Clin Invest Med.* 2009;32(3):E239–E249.

6. Gorey KM, Luginaah IN, Holowaty EJ, Fung KY, Hamm C. Breast cancer survival in Ontario and California, 1998 to 2006: socioeconomic inequity remains much greater in the United States. *Ann Epidemiol.* 2009;19(2):121–124.

7. Steering Committee. *Canadian Cancer Statistics, 2009.* Toronto, Ontario: Canadian Cancer Society; 2009.

8. Horner MJ, Ries LAG, Krapcho M, et al., eds. *SEER Cancer Statistics Review, 1975–2006.* Bethesda, MD: National Cancer Institute; 2009.

9. Gorey KM, Holowaty EJ, Fehringer G, Laukkanen E, Richter NL, Meyer CM. An international comparison of cancer survival: relatively poor areas of Toronto, Ontario, and three US metropolitan areas. *J Public Health Med.* 2000;22(3):343–348.

10. Zhang-Salomons J, Qian H, Holowaty E, Mackillop WJ. Associations between socioeconomic status and cancer survival: choice of SES indicator may affect results. *Ann Epidemiol.* 2006;16(7):521–528.

11. Boyd C, Zhang-Salomons JY, Groome PA, Mackillop WJ. Associations between community income and cancer survival in Ontario, Canada, and the United States. *J Clin Oncol.* 1999;17(7):2244–2255.

12. Lincourt AE, Sing RF, Kercher KW, et al. Association of demographic and treatment variables in long-term colon cancer survival. *Surg Innov.* 2008;15(1):17–25.

13. Polednak AP. Poverty, comorbidity, and survival of colorectal patients in Connecticut. *J Health Care Poor Underserved.* 2001;12(3):302–310.

14. Chao A, Connell CJ, Cokkinides V, Jacobs EJ, Calle EE, Thun MJ. Underuse of screening sigmoidoscopy and colonoscopy in a large cohort of US adults. *Am J Public Health.* 2004;94(10):1775–1781.

15. Bressler B, Lo C, Amar J, et al. Prospective evaluation of screening colonoscopy: who is being screened? *Gastrointest Endosc.* 2004;60(6):921–926.

16. Wirtzfeld DA, Mikula L, Gryfe R, et al. Concordance with clinical practice guidelines for adjuvant chemotherapy in patients with stage I-III colon cancer: experience in 2 Canadian provinces. *Can J Surg.* 2009;52(2):92–97.

17. Figueredo A, Coombes ME, Mukherjee S. Adjuvant therapy for completely resected stage II colon cancer. *Cochrane Database Syst Rev.* 2008;(3):CD005390.

18. Etzioni DA, El-Khoueiry AB, Beart RW. Rates and predictors of chemotherapy use for stage III colon cancer: a systematic review. *Cancer.* 2008;113(12):3279–3289.

19. Thorpe LE, Mostashari F, Hajat A, et al. Colon cancer screening practices in New York City, 2003: Results of a large random-digit dialed telephone survey. *Cancer.* 2005;104(5):1075–1082.

20. Halpern MT, Pavluck AL, Ko CY, Ward EM. Factors associated with colon cancer stage at diagnosis. *Dig Dis Sci.* 2009;54(12):2680–2693.

21. Schwartz KL, Crossley-May H, Vigneau FD, Brown K, Banerjee M. Race, socioeconomic status and stage at diagnosis for five common malignancies. *Cancer Causes Control.* 2003;14(8):761–766.

22. VanEenwyk J, Campo JS, Ossiander EM. Socioeconomic and demographic disparities in treatment of carcinoma of the colon and rectum. *Cancer.* 2002;95(1):39–46.

23. Singh SM, Paszat LF, Li C, He J, Vinden C, Rabeneck L. Association of socioeconomic status and receipt of colorectal cancer investigations: a population-based retrospective cohort study. *CMAJ.* 2004;171(5):461–465.

24. Gorey KM, Holowaty EJ, Laukkanen E, Fehringer G, Richter NL. An international comparison of cancer survival: advantage of Toronto's poor over the near poor of Detroit. *Can J Public Health.* 1998;89(2):102–104.

25. *International Classification of Diseases, Ninth Revision.* Geneva, Switzerland: World Health Organization; 1980.

26. *Profiles of Census Tracts and Census Subdivisions, 2001 (Ontario).* Ottawa: Statistics Canada; 2002.

27. *2000 Census of Population and Housing in California: Summary Tape File 3 on CD-ROM.* Washington, DC: US Census Bureau; 2002.

28. Fleiss JL. *Statistical Methods for Rates and Proportions.* 2nd ed. New York, NY: John Wiley & Sons; 1981.

29. Hall S, Schulze K, Groome P, Mackillop W, Holowaty E. Using cancer registry data for survival studies: the example of the Ontario Cancer Registry. *J Clin Epidemiol.* 2006;59(1):67–76.

30. Walter SD, Birnie SE, Marrett LD, et al. The geographic variation of cancer incidence in Ontario. *Am J Public Health.* 1994;84(3):367–376.

31. North American Association of Central Cancer Registries. Data quality assessments, 2008. Available at: http://www.naaccr.org. Accessed May 12, 2009.

32. National Cancer Institute. Surveillance, epidemiology, and end results (SEER), 2008. Available at: http://www.seer.cancer.gov. Accessed May 12, 2009.

33. California Cancer Registry. *Cancer Reporting in California: Abstracting and Coding Procedures for Hospitals. California Cancer Reporting System Standards.* Vol 1. 7th ed. Sacramento, CA: Department of Health Services, Cancer Surveillance Section; 2003.

34. Greene FL, Page DL, Fleming ID, et al., eds. *AJCC Staging Manual.* 6th ed. New York, NY: Springer-Verlag; 2002.

35. Fritz A, Ries L, eds. *SEER Extent of Disease: Codes and Coding Instructions.* 3rd ed. Bethesda, MD: National Cancer Institute; 1998.

36. Osberg L. Poverty in Canada and the United States: measurement, trends, and implications. *Can J Econ.* 2000;33(4):847–877.

37. Gorey KM, Vena JE. The association of near poverty status with cancer incidence among Black and White adults. *J Community Health.* 1995;20(4):359–366.

38. Krieger N, Chen JT, Waterman PD, Rehkopf DH, Subramanian SV. Race/ethnicity, gender, and monitoring socioeconomic gradients in health: a comparison of area-based socioeconomic measures—the Public Health Disparities Geocoding Project. *Am J Public Health.* 2003;93(10):1655–1671.

39. Krieger N, Chen JT, Waterman PD, Soobader M, Subramanian SV, Carson R. Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: does the choice of area-based measure and geographic level matter? The Public Health Disparities Geocoding Project. *Am J Epidemiol.* 2002;156(5):471–482.

40. Organization for Economic Co-Operation and Development. Purchasing power parities. Available at: http://www.oecd.org/std/ppp. Accessed February 12, 2009.

41. Lafrance R, Schembri L. Purchasing-power parity: definition, measurement, and interpretation. *Bank Can Rev.* Autumn 2002:27–33.

42. Hosmer DW, Lemeshow S. *Applied Logistic Regression.* 2nd ed. New York, NY: John Wiley & Sons; 2000.

43. Gorey KM. Regarding "Associations between socioeconomic status and cancer survival." *Ann Epidemiol.* 2006;16(10):789–791.

44. Greenland S. Introduction to regression modeling. In: Rothman KJ, Greenland S, eds. *Modern Epidemiology.* 2nd ed. Philadelphia, PA: Lippincott-Raven Publishers; 1998:401–432.

45. Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. *J Natl Cancer Inst.* 1959;22(4):719–748.

46. Miettinen OS. Estimability and estimation in case-referent studies. *Am J Epidemiol.* 1976;103(2):226–235.

47. Wright FC, Law CHL, Berry S, Smith AJ. Clinically important aspects of lymph node assessment in colon cancer. *J Surg Oncol.* 2009;99(4):248–255.

48. Bilimoria KY, Bentrem DJ, Stewart AK, et al. Lymph node evaluation as a colon cancer quality measure: a national hospital report card. *J Natl Cancer Inst.* 2008;100(18):1310–1317.

49. Chang GJ, Rodriguez-Bigas MA, Skibber JM, Moyer VA. Lymph node evaluation and survival after curative resection of colon cancer: systematic review. *J Natl Cancer Inst.* 2007;99(6):433–441.

50. Starfield B. Commentary: how does 'insurance' improve equity in health? *Int J Epidemiol.* 2009;38(6):1551–1553.

51. De Bosset V, Atashili J, Miller W, Pignone M. Health insurance-related disparities in colorectal cancer screening in Virginia. *Cancer Epidemiol Biomarkers Prev.* 2008;17(4):834–837.

52. Halpern MT, Ward EM, Pavluck AL, Schrag NM, Bian J, Chen AY. Association of insurance status and ethnicity with cancer stage at diagnosis for 12 cancer sites: a retrospective analysis. *Lancet Oncol.* 2008;9(3):222–231.

53. Bradley CJ, Given CW, Roberts C. Late stage cancers in a Medicaid-insured population. *Med Care.* 2003;41(6):722–728.

54. Bradley CJ, Given CW, Dahman B, Fitzgerald TL. Adjuvant chemotherapy after resection in elderly Medicare and Medicaid patients with colon cancer. *Arch Intern Med.* 2008;168(5):521–529.

55. McDavid K, Tucker TC, Sloggett A, Coleman MP. Cancer survival in Kentucky and health insurance

coverage. *Arch Intern Med.* 2003;16(18)3:2135–2144.

56. Bradley CJ, Given CW, Roberts C. Disparities in cancer diagnosis and survival. *Cancer.* 2001;91(1):178–188.

57. Roetzheim RG, Pal N, Gonzalez EC, Ferrante JM, Van Durme DJ, Krischer JP. Effects of health insurance and race on colorectal cancer treatments and outcomes. *Am J Public Health.* 2000;90(11):1746–1754.

58. Rabeneck L, Paszat LF. A population-based estimate of the extent of colorectal cancer screening in Ontario. *Am J Gastroenterol.* 2004;99(6):1141–1144.

59. Cancer Care Ontario. Colon cancer check. Available at: http://www.coloncancercheck.ca. Accessed May 24, 2009.

60. Gross CP, Smith BD, Wolf E, Andersen M. Racial disparities in cancer therapy: did the gap narrow between 1992 and 2002? *Cancer.* 2008;112(4):900–908.

61. Le H, Ziogas A, Lipkin SM, Zell JA. Effects of socioeconomic status and treatment disparities in colorectal cancer survival. *Cancer Epidemiol Biomarkers Prev.* 2008;17(8):1950–1962.

62. Du XL, Meyer TE, Franzini L. Meta-analysis of racial disparities in survival in association with socioeconomic status among men and women with colon cancer. *Cancer.* 2007;109(11):2161–2170.

63. Gomez SL, O'Malley CD, Stroup A, Shema SJ, Satariano WA. Longitudinal, population-based study of racial/ethnic differences in colorectal cancer survival: impact of neighborhood socioeconomic status, treatment and comorbidity. *BMC Cancer.* 2007(7):193.

64. Jargowsky PA. *Poverty and Ghettos Place: Barrios, and the American City.* New York, NY: Russell Sage Foundation; 1997.

65. Lund MJ, Brawley OP, Ward KC, Young JL, Gabram SS, Eley JW. Parity and disparity in first course treatment of invasive breast cancer. *Breast Cancer Res Treat.* 2008;109(3):545–557.

66. Malin JL, Kahn KL, Adams J, Kwan L, Laouri M, Ganz PA. Validity of cancer registry data for measuring the quality of breast cancer care. *J Natl Cancer Inst.* 2002;94(11):835–844.

67. Cress RD, Zaslavsky AM, West DW, Wolf RE, Felter MC, Ayanian JZ. Completeness of information on adjuvant therapies for colorectal cancer in population-based cancer registries. *Med Care.* 2003;41(9):1006–1012.

68. Cooper GS, Virnig B, Klabunde CN, Schussler N, Freeman J, Warren JL. Use of SEER–Medicare data for measuring cancer surgery. *Med Care.* 2002;40(8):IV-43–IV-48.

69. Brown BW, Brauner C, Minnotte MC. Noncancer deaths in White adult cancer patients. *J Natl Cancer Inst.* 1993;85(12):979–987.

70. Lenfant C, Freidman L, Thom T. Fifty years of death certificates: the Framingham Heart Study. *Ann Intern Med.* 1998;129(12):1066–1067.