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Abstract

Background
In developed countries, women of higher socio-economic status often have higher breast cancer incidence rates, compared with women of lower socio-economic status.

Data and methods
Data were extracted from the Canadian Cancer Registry for the 229,955 cases of adult female invasive breast cancer diagnosed from 1992 through 2004. Postal code at diagnosis was used to determine neighbourhood income quintile. Breast cancer incidence was examined by year, region, age and neighbourhood income quintile. Census data for 1991 on children ever born and British Columbia data for 2006 on first-time attendance at mammography screening were analyzed by neighbourhood income quintile.

Results
Residence in the lowest as opposed to the highest neighbourhood income quintile was associated with a 15% lower risk of being diagnosed with breast cancer. Higher income levels were associated with lower parity in 1991 and a higher prevalence of first-time screening mammography in British Columbia in 2006.

Interpretation
Canadian data support an association between the diagnosis of invasive breast cancer and neighbourhood income quintile. Parity and mammography screening may account for some differences in incidence.

Keywords
Mammography screening, parity, Poisson regression, record linkage, small-area analysis, social class, socioeconomic factors

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Incidence and mortality rates for most chronic diseases including several types of cancer are higher among people of lower socio-economic status.[1,2] By contrast, for female breast cancer in developed countries, the relationship may be inverted, with women of higher socio-economic status having higher rates,[3-11] even when risk factors that differ by socio-economic status such as parity, age at first birth and hormone use[12] are taken into account. Only one earlier study examined the risk of breast cancer in relation to socio-economic status in Canada,[13] and it focused on the effects of passive smoking.

The purpose of the present study was to examine the association between neighbourhood income and the diagnosis of female breast cancer. Population data from the Canadian Cancer Registry were used to calculate national age-specific and age-standardized incidence rates of breast cancer from 1992 through 2004 by neighbourhood income quintile and region. At the outset, it is recognized that area-based analyses such as this cannot disentangle associations with income itself from neighbourhood context, nor can they establish causal relationships.

Data and methods

Case selection

All incident cases of invasive breast cancer diagnosed from January 1, 1992 through December 31, 2004 among Canadian women aged 19 or older were eligible for inclusion in this study. Cases were identified from the Canadian Cancer Registry, accessed via the Statistics Canada Research Data Centre at the University of British Columbia.

Of the 229,955 incident cases in the registry during the period, 3,750 (1.6%)

were excluded because of missing, invalid or non-residential postal codes, and 37 because the women were younger than 19 at diagnosis. This left 226,169 (98.4%) cases.

No personal identifiers other than the 6-digit postal code in the cancer registries were used. The study was approved by the joint British Columbia Cancer Agency/University of British Columbia Research Ethics Board.

Data sources and variables

The data obtained from the Canadian Cancer Registry for each breast cancer case were: age at diagnosis, year of diagnosis, and postal code of usual place of residence at the time of diagnosis. Only the first three digits of the postal code were available for cases diagnosed in Quebec. For the denominators, population data by census year (1991, 1996, 2001, and 2006) and by 5-year age group were obtained from Statistics Canada for enumeration areas (1991 and 1996) and dissemination areas (2001 and 2006), the smallest geographic units for which population data are released. Data for non-census years were interpolated from values for the closest census years.

To partially compensate for the lack of individual data on reproductive risk factors, 1991 census data on number of children ever born per 1,000 women aged 15 or older (parity) were used; these data were compiled by neighbourhood income quintile and region. Information for 1991 was used because this question was not asked on later censuses.

The possible effect differential use of screening mammography was examined by neighbourhood income quintile with already-extracted 2006 British Columbia data on first-time screening mammography attendance, compiled by neighbourhood income quintile as determined by postal code at the time of screening.

Neighbourhood income quintiles

Neighbourhood income quintiles were defined for enumeration and dissemination areas according to methods developed at Statistics Canada, and assigned based on the postal code of the subject's usual place of residence at the time of breast cancer diagnosis. Quintile values were determined for each census during the study period. The value derived from the census closest to the diagnosis date was assigned to each subject's record.[8]

Based on the postal code, the corresponding 1996 census enumeration areas and 2001 and 2006 dissemination areas were determined using Statistics Canada's postal code conversion software (*PCCF+ Version 4J*). Additional files were used to determine the corresponding 1991 census enumeration areas, based on the nearest centroids (central points described by longitude and latitude) of those areas with respect to the 1996 enumeration area centroids. Neighbourhood income data were obtained from the census closest to the diagnosis date.

Neighbourhood income quintiles were based on average income per single-person equivalent in the enumeration area or dissemination area. This measure uses the person-weights implicit in the Statistics Canada low-income cut-offs to derive "single-person equivalent" multipliers for each household size. This is a way of adjusting for household size, since more sophisticated variables were not available for enumeration areas before 2001. Population quintiles by neighbourhood income were constructed within each area (census metropolitan area, census agglomeration or residual areas in each province), then pooled across areas. Because housing costs vary substantially across Canada, area-based quintiles better reflect income adequacy relative to need.

Statistical analysis

Female breast cancer incidence rates were calculated for each 10-year age group, year of diagnosis, region and neighbourhood income quintile, using Orius 98 Manager software.[14] The 10 provinces and 3 territories were grouped into 5 regions: British Columbia; Prairies and Territories (Alberta, Saskatchewan, Manitoba, Yukon, Northwest Territories, and Nunavut; the combined population of the territories was less than 2% of the population of the Prairie provinces); Ontario; Quebec; and Atlantic (Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador).

Age-standardized breast cancer incidence rates (ASIR) per 100,000 female person-years at risk were computed by the direct method using the 1991 population of Canada as the standard. Rate ratios (RR, a measure of relative risk) with 95% confidence intervals based on the Poisson distribution were computed from the ASIR for each neighbourhood income quintile relative to the highest income quintile, with year of diagnosis as a co-variate and stratified by 10-year age group. Tests for heterogeneity and trend in the RRs were calculated using the likelihood ratio test from the standard technique of Poisson regression.[15] Differences in neighbourhood income quintile RRs across age and year were tested using interaction terms in the Poisson regression model.

Data on the number of children ever born per 1,000 women aged 15 or older were compiled by neighbourhood income quintile for 1991.

Data for 2006 from the British Columbia Screening Mammography Program were examined by neighbourhood income quintile as determined by postal code at time of attendance. The percentage of women aged 30 to 89 undergoing screening mammography for the first time was calculated.

Results

Age group and neighbourhood income quintile

For women in all age groups, the risk of being diagnosed with breast cancer was greatest in the highest neighbourhood income quintile (Table 1). Compared with women in neighbourhoods in the top quintile, the RRs for those in the lowest, second-lowest, middle, and second-highest quintiles were lower: 0.85, 0.89, 0.92 and 0.95, respectively.

Table 1
Incident cases of female breast cancer, age-standardized incidence rates, and rate ratios, by age group and neighborhood income quintile, Canada, 1992 to 2004

Age group (years)/ Neighbourhood income quintile	Number of cases	Age-standardized incidence rate (per 100,000)	Rate ratio† %	95% confidence interval from	to
Total 19 or older					
1 (lowest)	44,138	114.21	0.85	0.84	0.86
2	45,671	119.69	0.89	0.88	0.90
3	44,693	117.70	0.92	0.91	0.93
4	44,544	117.47	0.95	0.94	0.96
5 (highest)	47,943	128.00	1.00	...	...
19 to 39					
1 (lowest)	2,247	10.25	0.75*	0.72	0.78
2	2,396	11.39	0.83*	0.80	0.87
3	2,631	12.47	0.91*	0.88	0.95
4	2,759	13.04	0.96	0.93	1.00
5 (highest)	2,709	13.58	1.00	...	...
40 to 49					
1 (lowest)	6,631	129.91	0.93*	0.91	0.95
2	7,486	135.35	0.97*	0.95	0.99
3	7,830	132.42	0.95*	0.93	0.97
4	8,431	133.62	0.96*	0.94	0.98
5 (highest)	9,474	141.19	1.00	...	...
50 to 59					
1 (lowest)	9,032	238.98	0.91*	0.90	0.93
2	9,777	239.92	0.93*	0.91	0.94
3	10,193	242.03	0.94*	0.92	0.96
4	11,010	252.57	0.99	0.97	1.01
5 (highest)	12,082	255.50	1.00	...	...
60 to 69					
1 (lowest)	9,944	305.13	0.85*	0.84	0.87
2	10,524	317.57	0.90*	0.88	0.92
3	10,168	323.12	0.93*	0.91	0.94
4	9,970	333.11	0.96*	0.94	0.97
5 (highest)	10,439	347.72	1.00	...	...
70 or older					
1 (lowest)	16,284	354.60	0.80*	0.79	0.82
2	15,488	368.32	0.85*	0.84	0.86
3	13,871	385.12	0.89*	0.88	0.91
4	12,384	397.29	0.92*	0.90	0.94
5 (highest)	13,239	431.94	1.00	...	...

† reference category is highest neighbourhood income quintile (5)
* significantly different from reference category
... not applicable
Source: Canadian Cancer Registry; 1991, 1996, 2001 and 2006 Census of Canada.

This pattern was most pronounced among women aged 19 to 39 or 70 or older, among whom the reductions in risk were 25% and 20%, respectively, for those in the lowest as opposed to the highest income quintile. The corresponding risk reductions were attenuated (ranging from 7% to 15%) but still statistically significant in the other age groups.

In each region, differences in breast cancer ASIRs among the first four neighbourhood income quintiles were relatively small (and often not statistically significant), but the difference was much larger (and always significant) between the fourth and fifth (Figure 1).

Parity

In 1991, in all regions except British Columbia, the number of children ever born per 1,000 women aged 15 or older was inversely related to neighbourhood income quintile (Figure 2). Regional differences were striking: women in each neighbourhood income quintile in Atlantic Canada had, on average, about 50% more children than did their counterparts in British Columbia.

Trends and birth cohorts

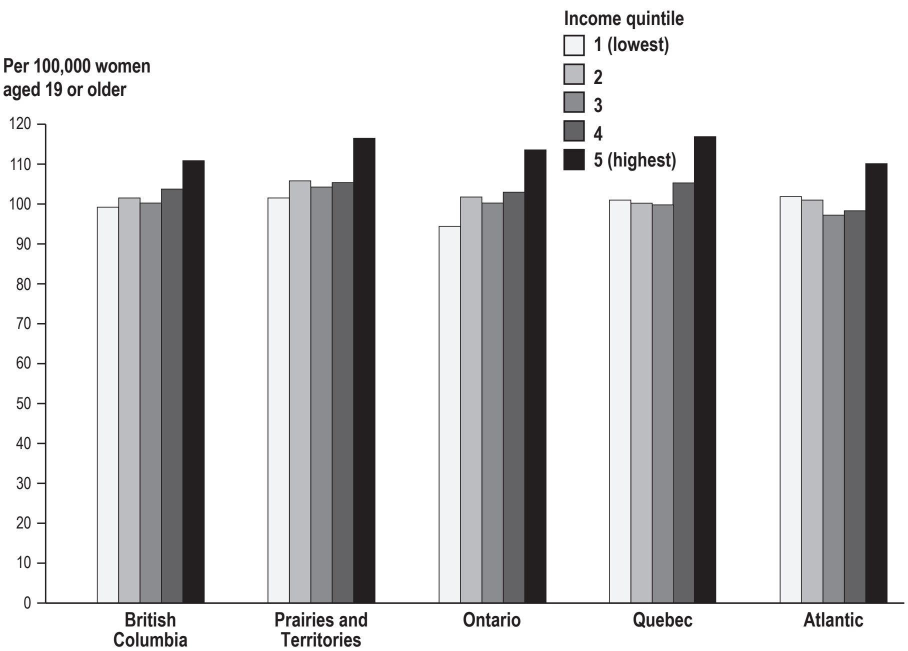
Overall, breast cancer ASIRs in all neighbourhood income quintiles had declined slightly by 2004, following a short-term rise in the late 1990s that coincided with the uptake of screening mammography offered by provincial programs. However, throughout the period, the association between higher neighbourhood income and higher breast cancer incidence persisted. The greatest difference in ASIRs between adjacent income quintiles was between the fourth and fifth, although the gap widened from 1995 to 1998, and then narrowed from 2002 to 2004.

To investigate possible birth cohort effects, breast cancer ASIRs for women aged 50 to 59, 60 to 69, and 70 or older were examined by neighbourhood income and year of diagnosis (Figure 3). The two-way interaction of neighbourhood income quintile RR across each age group and year ($p<0.001$ in each case) was also tested. Over the 13-year period, in all neighbourhood income quintiles, breast cancer incidence rates were stable or rose slightly among women in their 50s and 60s, but declined among women aged 70 or older. For women in their 60s and 70 or older, the gap in incidence rates across the income quintiles widened in the first few years of the period and persisted through 2004.

Screening mammography

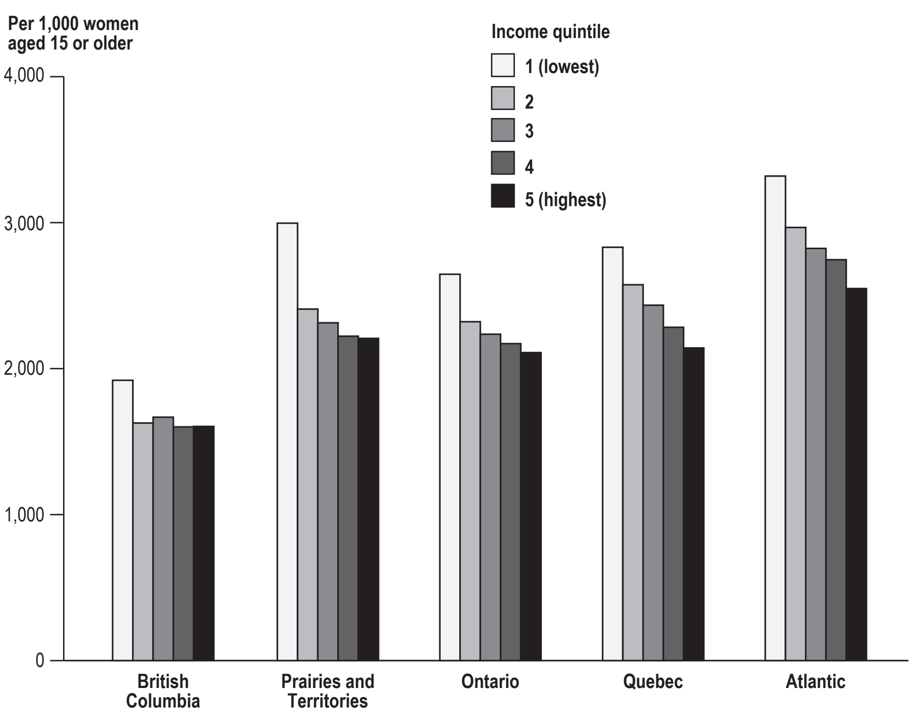
For British Columbia women in each age group (except 70 to 79), those in higher-income neighbourhoods tended to be more likely to have presented for a first mammogram, compared with those in lower-income neighbourhoods (Figure 4).

Figure 1
Age-standardized incidence rates for female breast cancer, by neighbourhood income quintile and region, Canada, 1992-2004



Source: Canadian Cancer Registry; 1991, 1996, 2001 and 2006 Census of Canada.

Figure 2
Children ever born, by neighbourhood income quintile and region, Canada, 1991



Source: 1991 Census.

Discussion

This analysis of breast cancer incidence rates by neighbourhood income quintile revealed a 15% lower risk of diagnosis among women in the lowest quintile, compared with those in the highest. Similar patterns for breast cancer in relation to individual socio-economic status, as measured by education, were reported for a Norwegian prospective cohort.[16] An earlier study of breast cancer *mortality* in urban Canada[1] found a 12% lower risk in the lowest compared with the highest neighbourhood income quintile.

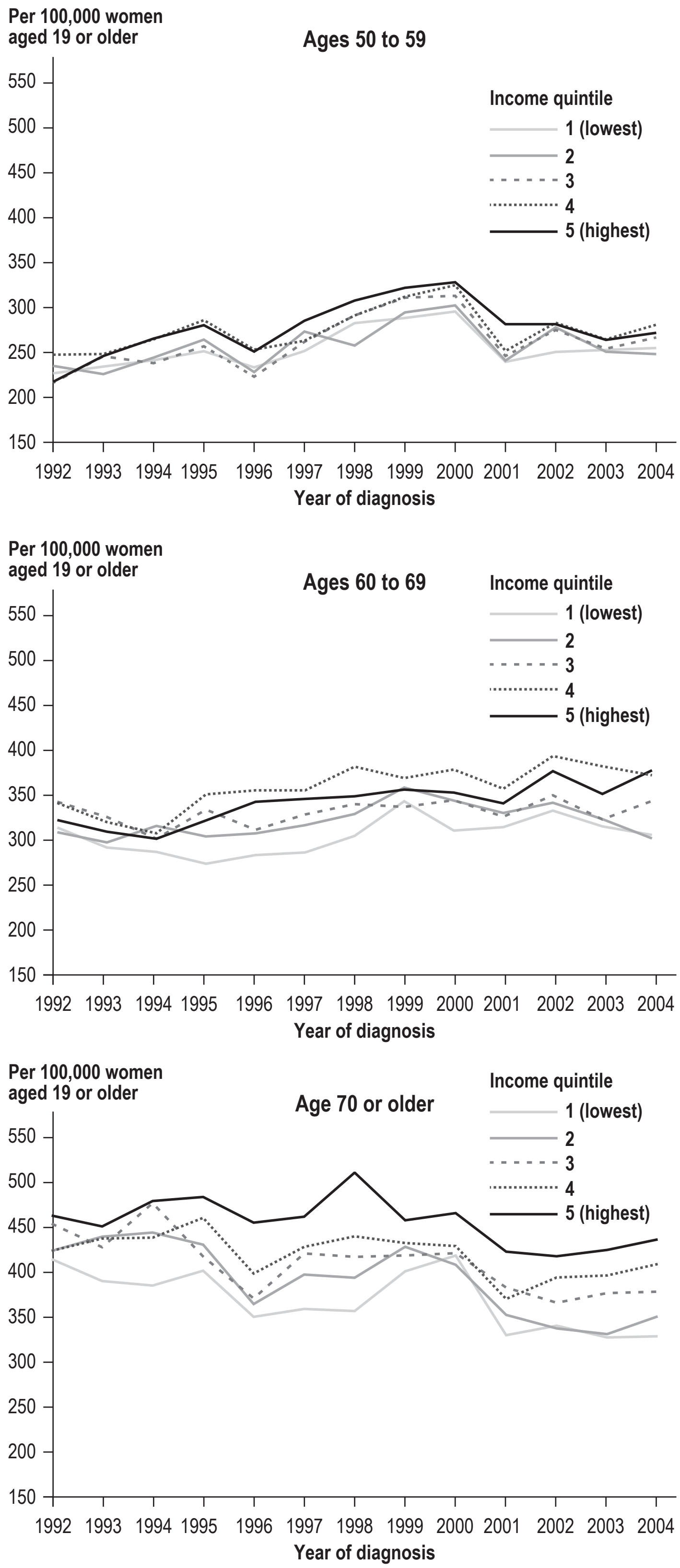
The association between breast cancer risk and neighbourhood income may be partly explained by the distribution of risk factors such as parity or age at first birth that also vary with socio-economic status, as has been reported in some [17,18] but not all[12] studies.

Parity may influence breast cancer risk through the reduction of estrogen exposure during the months when no menstrual cycles are experienced.[19-23] And indeed, women in higher-income neighbourhoods tended to have fewer children than did those in lower-income neighbourhoods. However, the major difference in parity was between the first (lowest) and second (next lowest) income quintiles, while the major difference in breast cancer incidence was between the fourth and fifth (highest) quintiles. Moreover, the association between parity and breast cancer incidence did not apply across regions. For example, among the regions, parity was lowest for British Columbia women, but British Columbia's breast cancer incidence rates were also among the lowest.

The availability of data by age group from 1992 to 2004 made it possible to consider possible birth cohort effects. The results showed a decline in incidence among women aged 70 or older, but a rise among those aged 50 to 59.

In a 1987 paper,[24] White et al. examined the changes in breast cancer risk that would be expected if age at first birth was the only factor at work. That study may help to explain the results of

Figure 3
Age-standardized breast cancer incidence rates, by neighbourhood income quintile, year of diagnosis and age group, Canada, 1992 to 2004



Source: Canadian Cancer Registry; 1991, 1996, 2001 and 2006 Census of Canada.

What is already known on this subject?

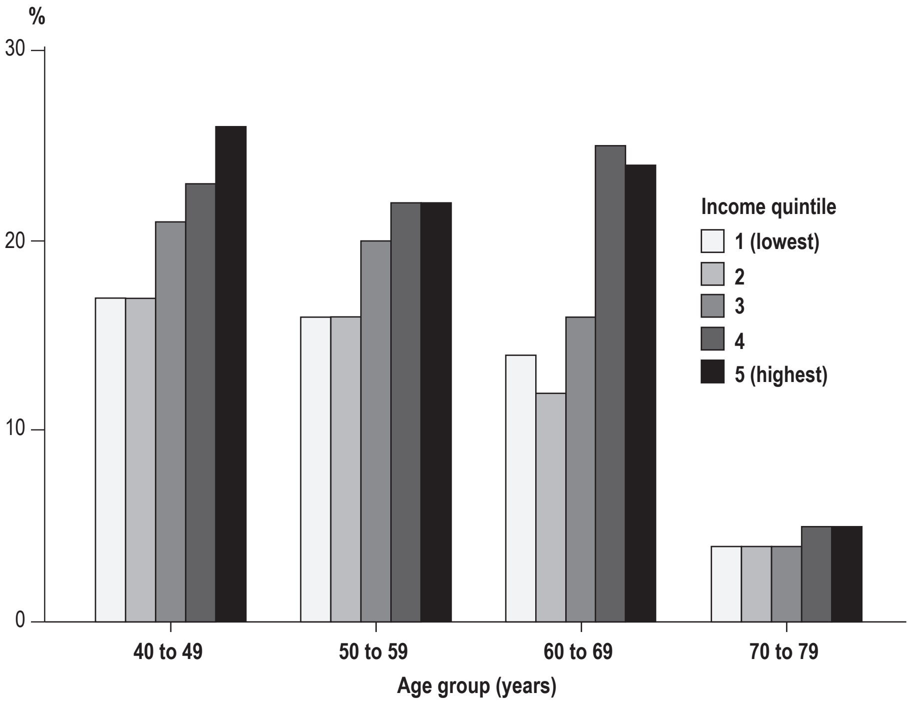
- Data from other countries indicate an elevated risk of breast cancer among women of higher socio-economic status.
- Factors such as number of children even born (parity) and participation in screening mammography, which also vary by socio-economic status, may be responsible for the association.

What does this study add?

- Across Canada over a recent 13-year period, breast cancer incidence rates were highest in the most affluent neighbourhoods, and considerably lower in all other neighbourhoods.
- Lower parity and a higher prevalence of screening mammography may be related to the higher breast cancer incidence rates among women in the highest neighbourhood income quintile, but these factors did not fully explain the differences across income categories.

the present analysis. Women who were aged 70 or older in 1992 had been in the family formation stage in the 1940s, when births were delayed, notably as a result of World War II; this potentially conferred a higher breast cancer risk on them. By contrast, women who were in their 70s in 2004 had entered their child-bearing years during the postwar baby-boom and so may have been at lower risk of breast cancer due to earlier ages at first birth. The risk profile of 50- to 59-year-olds also changed over the study period, as the women who had started families in the early 1960s were succeeded by those who started families in the 1970s when the trend was toward later ages at first birth. Thus, women in their 50s at the end of the study period may have been at greater risk of breast cancer than was the case for the previous generation.

Figure 4
Percent of eligible population aged 40 to 79 attending first-time screening mammography, by neighbourhood income quintile and age group, British Columbia, 2006



Source: British Columbia Screening Mamography Program; 2006 Census of Canada.

Consistent with earlier research,[25] the present analysis shows a strong positive association between participation in screening mammography and neighbourhood income quintile among women aged 40 to 69.

A positive association between socio-economic status and breast cancer has been reported in many developed countries,[3-4, 7] but over time, rates among women of lower socio-economic status have started to "catch up".[26] For example, area-based socio-economic disparities in breast cancer incidence in the United States levelled off or narrowed after 2000,[27] similar to the difference reported in the present study between the fourth (second highest) and fifth (highest) income quintiles.

But even taking individual-level indicators of socio-economic status and known risk factors into account, Robert et al.[12] showed that area-based measures of socio-economic status continued to be associated with breast cancer risk. This suggests that area-based measures are not just proxies for individual-level socio-economic status, but may represent additional factors. Future analysis of data from prospective cohorts would allow comparison of individual and neighbourhood factors, as well as lifestyle, family history, occupational and residential history, and biologic sample data collected before the onset of disease.

Limitations

The design of this study limited the investigation of factors that might help explain why living in a higher-income neighbourhood would be associated with a higher risk of being diagnosed with breast cancer. The use of small-area data meant that it was not possible to directly adjust for individual-level risk factors. Moreover, only one postal code (residence at diagnosis) was available, so the income quintile of neighbourhoods where women with breast cancer had lived at potentially relevant earlier periods could not be considered. As well, national cancer registration data contain no staging information.

Only the first three digits of the postal code were available for cases diagnosed in Quebec, thereby yielding less precise estimates of neighbourhood income quintile. Such non-differential misclassification would tend to attenuate effect estimates, thus diminishing the association between diagnosis and neighbourhood income, especially for Quebec.

Data on the two factors that might contribute to the results—parity and mammography—were also limited. Census parity data were available only for 1991. Screening mammography data pertained to British Columbia, and to first-time attendance, which may differ from return attendance with respect to important factors such as age. However, differential access to medical care or screening[28] were unlikely to have been major factors because of publicly funded universal health care in Canada.

The small percentage of cases that were excluded was unlikely to have biased the results.

Conclusion

Breast cancer incidence is one of the few adverse health outcomes consistently associated with higher socio-economic status. The association may be partly related to differences in parity and screening mammography, but other factors remain to be identified. Additional research on neighbourhood-level differences would be beneficial in informing public health strategies for breast cancer prevention. ■

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