ABSTRACT

The primary purpose of this study was to assess whether Sydney, Industrial Cape Breton County excluding Sydney (ICBxS) and Cape Breton County (CBCo) residents were at increased risk for cancer compared to Nova Scotia (NS) residents over five-year periods during 1979 through 1997. Gender-stratified, age-standardized cancer incidence rates were calculated following the direct method. All-cause rates were higher for female and male residents of Sydney, ICBxS and CBCo compared to NS based upon both municipality and postal code methods of residence classification. A sensitivity analysis of residential coding yielded a high degree of consistency for all geographies except Sydney, limiting comparisons of Sydney rates with other local geographies except where consistencies were observed. The results of this ecological study support the need for further analysis of factors contributing to the increased risk for cancer in CBCo.

ABRÉGÉ

Le but principal de cette étude était de déterminer si les habitants de Sydney, du comté industriel du Cap Breton excluant Sydney (CICBxS) et du comté de Cap Breton (CCB), étaient en danger élevé du cancer, comparé aux habitants de la Nouvelle-Écosse (N-É), pendant des périodes de cinq ans de 1979 jusqu'à 1997. Les taux d'incidence du cancer, standardisés selon l'âge et le genre, ont été calculés selon la méthode directe. Les taux de cause étaient plus élevés pour les habitants mâles et femelles de Sydney, CICBxS et CCB comparé à la N-É basé sur les méthodes de code postal et de municipalité pour la classification résidentielle. Une analyse de sensibilité de programmation résidentielle a démontré une forte cohérence pour toutes régions sauf Sydney, limitant la possibilité de comparaison des taux de Sydney avec les autres régions sauf où les cohérences étaient observées. Les résultats de cette étude écologique soutiennent le besoin pour une analyse plus approfondie des facteurs contribuant au risque de cancer élevé dans le CCB.

Incidence of Cancer in Sydney and Cape Breton County, Nova Scotia 1979-1997

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Elevated concentrations of air pollutants from the Sydney Steel Corporation^{1,2} and toxic emissions from the Sydney Tar Ponds³ have been documented by numerous studies of Sydney, Nova Scotia since the early 1960s. While air quality has improved since the closure of the coke ovens in 1988,⁴ the carcinogen-containing residues in the Tar Ponds remain.⁵ Recent evidence suggests that some Sydney residential soils contain higher than acceptable concentrations of PAHs and metals.⁶

That these environmental conditions may have had a health impact is suggested by ecological studies of Sydney and Cape Breton County mortality. Significant deficiencies in life expectancy for male and female Sydney residents compared to Canadians since the early 1960s were recently described by our group; cancer and cardiovascular disease were the most significant contributors to excess life loss.⁷ Band and Camus⁸ have also reported increased occurrence of cancer mortality over a 45-year period for Sydney residents. Higher mortality rates, particularly cancer, for the earlier period of 1979-1983 for census subdivisions of Cape Breton County were previously described.⁹ Yet, these studies do not provide estimates of cancer incidence.

Incidence data serve as a better marker of etiology than mortality data; they are less clouded by issues of access and delivery of health care. Furthermore, cancer registry data are regarded to be more accurate than death certificate information; the quality and completeness of the Nova Scotia data are augmented by the fact that formal reporting of cancers to the Cancer Registry is required by law in this province. This contrasts with other parts of Canada where some provincial cancer registries rely upon passive reporting methods.¹⁰

Sydney represents an important opportunity to examine the interplay of forces that serve as environmental determinants of health status. Acquiring and maintaining the health of populations despite economic pressures is an integral aspect of achieving sustainable development.¹¹ The health barriers posed by poor physical environments within communities are not well understood. The application of ecological data to examine incidence trends may facilitate elucidation of contributory etiological factors.

The principal aim of this hypothesis screening study¹² was to assess whether residents of Sydney, Industrial Cape Breton County excluding Sydney (ICBxS) and Cape Breton County (CBCo) were at increased risk for developing cancer compared to the Nova Scotia (NS) population during the period 1979 through 1997. Secondly, we wished to determine whether Sydney's residents are at greater risk for developing cancer than residents of other Industrial Cape Breton County (ICB) communities and than CBCo residents as a whole. These communities were chosen because, like Sydney, they are primarily working class NS communities. Finally we examined methodological issues regarding

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residential coding of the Cancer Registry records.

METHODS

Cancer incidence data for all major cancer sites coded to anatomical groupings by the ICD 9th revision classification system¹³ and by municipality were obtained from the NS Cancer Registry for the geographic areas of interest. Industrial Cape Breton (ICB) was defined as the six communities surrounding Sydney Harbour and included Dominion, Glace Bay, New Waterford, North Sydney, Sydney Mines and Sydney. These communities are located in close proximity with Sydney located near the centre of the region. All communities are located within CBCo, one of four counties located on Cape Breton Island. Sydney and ICBxS were classified into two mutually distinct demographic areas. Population census data for Canada, NS, CBCo and municipalities within CBCo for the years 1981, 1986, 1991, and 1996 for males and females, categorized into five-year age groups (to 90 years plus), were obtained from Statistics Canada.

Cases for each region were aggregated over intervals (1979-1983, 1984-1988, 1989-1993, 1994-1997) with the census year forming the mid-point. For 1994-1997, the interval was restricted to four years. For this period, interpolated census data for each age and gender category were created for the mid-point from the 1991 and 1996 information. The NS Cancer Registry have consistently applied the same geographic coding system used by Statistics Canada in the population census for assignment of municipality codes to NS populations. Thus, NS geographic reference areas are congruent for numerators and denominators. There have been no major changes in geographic boundaries of the ICB communities until 1995 when these communities were amalgamated to become the Cape Breton Regional Municipality. Even then, this change was for administrative purposes only; there have not been major shifts in the underlying population. Municipality of residence at time of diagnosis information in the cancer registry records was determined to be more than 90% available after 1978 and

TABLE 1A
Age-Adjusted Incidence Rates and 95% Confidence Intervals per 100,000 - Females -
Geographic Areas of Cape Breton County and Nova Scotia, 1979-1997 - Municipality-coded data

Cancer Site	Nova Scotia						Cape Breton County						Industrial Cape Breton County minus Sydney						Sydney					
	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97
All Causes	281.8	336.1	355.9	360.6	272.1	340.3	384.6	399.0	265.1	342.2	402.1	444.2	265.1	342.2	402.1	444.2	370.3	454.3	510.9	615.3	370.3	454.3	510.9	615.3
Stomach	274.5-289.2	328.5-343.8	348.6-363.3	352.5-368.6	253.4-290.7	320.1-360.4	364.3-404.9	376.3-421.7	235.7-294.5	310.0-374.4	368.9-435.4	405.3-483.1	235.7-294.5	310.0-374.4	368.9-435.4	405.3-483.1	328.2-412.5	407.5-501.1	463.7-558.1	554.3-676.4	328.2-412.5	407.5-501.1	463.7-558.1	554.3-676.4
Colon & Rectum	70-9.5	70-9.3	58-7.7	48-6.8	64-13.7	70-14.4	85-15.3	49-11.2	27-14.3	68-20.0	50-15.0	35-14.6	27-14.3	68-20.0	50-15.0	35-14.6	6.2-24.0	3.5-25.3	8.4-23.6	28-19.1	6.2-24.0	3.5-25.3	8.4-23.6	28-19.1
Pancreas	47.2	53.5	50.4	48.0	38.3	56.7	48.7	48.3	40.9	60.3	55.6	51.2	40.9	60.3	55.6	51.2	52.8	68.7	57.7	72.4	52.8	68.7	57.7	72.4
Lung and Pleura	44.2-50.1	50.5-56.6	47.7-53.1	45.2-50.9	31.4-45.3	48.6-64.8	41.7-55.7	40.8-55.9	29.1-52.8	47.3-73.3	43.7-67.6	38.8-63.6	29.1-52.8	47.3-73.3	43.7-67.6	38.8-63.6	37.6-68.0	50.4-87.1	42.8-72.6	53.5-91.2	37.6-68.0	50.4-87.1	42.8-72.6	53.5-91.2
Breast	59-8.1	77-10.2	74-9.6	72-9.6	24-7.4	61-12.9	66-12.6	43-10.1	3.0	39-14.9	50-14.4	31-12.7	3.0	39-14.9	50-14.4	31-12.7	4.2	8.5	8.7	10.3	4.2	8.5	8.7	10.3
Melanoma	23.4	33.9	41.7	46.3	23.6	40.2	45.5	53.3	25.0	42.8	48.4	59.8	25.0	42.8	48.4	59.8	26.1	49.8	54.9	82.5	26.1	49.8	54.9	82.5
Cervix	21.3-25.4	31.5-36.3	39.1-44.2	43.5-49.2	18.2-29.0	33.5-46.9	38.6-52.5	45.1-61.5	16.4-33.6	32.0-53.6	36.9-59.9	45.4-74.3	16.4-33.6	32.0-53.6	36.9-59.9	45.4-74.3	15.2-37.0	35.1-64.4	39.6-70.2	61.1-104	15.2-37.0	35.1-64.4	39.6-70.2	61.1-104
Corpus uteri	82.8	92.6	102.0	106.0	84.0	88.3	116.0	115.0	80.5	84.6	118.0	128.0	80.5	84.6	118.0	128.0	118.0	145.0	166.0	193.0	118.0	145.0	166.0	193.0
Ovary	78.8-86.8	88.6-96.7	97.6-106.0	102.0-111.0	73.6-94.4	78.0-98.6	105.0-127.0	103.0-128.0	64.5-96.6	68.6-101.0	99.9-136.0	107.0-148.0	64.5-96.6	68.6-101.0	99.9-136.0	107.0-148.0	94.0-143.0	119.0-171.0	139.0-194.0	158.0-228.0	94.0-143.0	119.0-171.0	139.0-194.0	158.0-228.0
Kidney	6.1-8.6	8.8-11.5	10.0-12.8	9.3-12.2	3.2-9.1	5.9-13.0	4.1-9.8	8.6-17.4	3.3-14.7	1.6-12.0	0.4-7.5	5.7-20.0	3.3-14.7	1.6-12.0	0.4-7.5	5.7-20.0	—	6.3-22.8	4.5-20.0	9.6-33.0	—	6.3-22.8	4.5-20.0	9.6-33.0
Bladder	10.7-13.9	11.7-14.8	11.8-14.7	9.7-12.6	12.7-22.8	13.5-23.4	15.4-25.5	9.8-19.2	10.1-25.9	12.4-30.2	10.8-26.8	5.8-20.0	10.1-25.9	12.4-30.2	10.8-26.8	5.8-20.0	14.3-38.1	12.5-34.6	15.2-38.4	14.0-44.9	14.3-38.1	12.5-34.6	15.2-38.4	14.0-44.9
Hematopoietic	16.2	17.8	17.6	17.8	15.8	16.3	20.5	21.8	14.0	12.8	22.7	25.6	14.0	12.8	22.7	25.6	21.7	20.2	25.9	32.5	21.7	20.2	25.9	32.5
Lymph Nodes	14.5-17.9	16.1-19.6	16.0-19.3	16.0-19.6	11.4-20.3	11.9-20.6	15.8-25.1	16.6-27.1	7.3-20.7	6.8-18.8	14.9-30.5	16.5-34.8	7.3-20.7	6.8-18.8	14.9-30.5	16.5-34.8	12.4-31.1	11-29.5	15.7-36.1	18.9-46.2	12.4-31.1	11-29.5	15.7-36.1	18.9-46.2
	14.3	14.9	15.4	15.7	12.8	13.5	13.0	16.9	11.5	14.0	10.9	18.7	11.5	14.0	10.9	18.7	18.3	19.0	17.5	25.1	18.3	19.0	17.5	25.1
	12.7-16.0	13.2-16.5	13.8-16.9	14.0-17.5	8.8-16.8	9.5-17.5	9.2-16.7	12.1-21.7	5.5-17.4	7.4-20.6	5.5-16.4	10.3-27.1	5.5-17.4	7.4-20.6	5.5-16.4	10.3-27.1	9.4-27.1	10.3-27.6	9.2-25.7	13.0-37.2	9.4-27.1	10.3-27.6	9.2-25.7	13.0-37.2
	5.0	7.5	9.3	8.6	6.5	8.6	8.8	10.5	9.6	8.6	7.6	12.6	9.6	8.6	7.6	12.6	5.2	8.9	12.6	13.8	5.2	8.9	12.6	13.8
	4.1-6.0	6.4-8.7	8.1-10.5	7.3-9.8	3.6-9.4	5.5-12.0	5.7-11.8	6.9-14.1	3.6-14.8	4.2-14.5	3.0-12.2	5.9-19.4	3.6-14.8	4.2-14.5	3.0-12.2	5.9-19.4	0.6-9.8	2.5-15.4	5.3-19.8	5.9-21.7	0.6-9.8	2.5-15.4	5.3-19.8	5.9-21.7
	5.9-8.2	7.5-9.9	7.9-10.2	8.2-10.7	3.8-9.5	5.4-11.8	5.2-11.0	10.0-18.5	2.2-11.0	2.9-13.0	3.1-11.9	8.1-22.8	2.2-11.0	2.9-13.0	3.1-11.9	8.1-22.8	2.7-15.3	4.7-18.7	3.8-18.4	4.7-20.1	2.7-15.3	4.7-18.7	3.8-18.4	4.7-20.1
	4.3	5.3	4.4	5.4	2.5	4.7	4.2	5.2	3.3	6.5	5.2	3.8	3.3	6.5	5.2	3.8	2.2	3.8	6.1	13.8	2.2	3.8	6.1	13.8
	3.4-5.2	4.3-6.2	3.5-5.2	4.4-6.4	0.8-4.1	2.3-7.1	2.0-6.4	2.5-7.9	0.4-6.2	1.5-11.5	1.0-9.3	0.4-7.2	0.4-6.2	1.5-11.5	1.0-9.3	0.4-7.2	—	—	1.1-11.1	3.2-24.3	—	—	1.1-11.1	3.2-24.3
	5.2	7.0	7.6	7.2	5.4	8.2	8.5	4.6	4.3	7.7	8.7	7.2	4.6	7.7	8.7	7.2	7.7	9.2	10.1	4.4	7.7	9.2	10.1	4.4
	4.2-6.2	5.9-8.1	6.5-8.7	6.0-8.4	2.7-8.8	5.0-11.4	5.4-11.6	2.1-7.1	0.4-8.1	2.7-12.6	3.8-13.6	1.9-12.6	0.4-8.1	2.7-12.6	3.8-13.6	1.9-12.6	1.3-14.1	2.7-15.7	3.3-16.8	—	1.3-14.1	2.7-15.7	3.3-16.8	—
	13.3	14.9	17.7	18.2	12.4	9.5	17.4	18.9	7.6	7.2	20.6	24.4	7.6	7.2	20.6	24.4	24.1	17.5	22.6	25.3	24.1	17.5	22.6	25.3
	11.7-14.9	13.3-16.6	16.1-19.4	16.4-20.0	8.4-16.5	6.2-12.8	13.0-21.8	13.8-24.1	2.8-12.4	2.7-11.7	13.0-28.1	14.6-34.2	2.8-12.4	2.7-11.7	13.0-28.1	14.6-34.2	12.4-35.9	5.8-22.9	12.8-32.4	11.9-38.7	12.4-35.9	5.8-22.9	12.8-32.4	11.9-38.7

Nova Scotia rates based on data for which there are valid municipal residential information only (number missing = 646); Industrial Cape Breton County (excluding Sydney) is defined as the six communities surrounding Sydney Harbour excluding Sydney; * = rate is significantly higher than Nova Scotia rate for the same time period.

TABLE IB
Age-Adjusted Incidence Rates and 95% Confidence Intervals per 100,000 - Males -
Geographic Areas of Cape Breton County and Nova Scotia, 1979-1997- Municipality-coded Data

Cancer Site	Nova Scotia				Cape Breton County				Industrial Cape Breton County minus Sydney				Sydney			
	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97	79-83	84-88	89-93	94-97
All Causes	352.7	453.2	488.6	485.3	330.9	492.1	538.7	591.5	357.4	517.2	570.9	678.1	445.1	662.5	706.4	838.4
Pharynx	343.8-361.6	443.3-463.2	479.1-498.1	475.0-495.7	307.3-354.4	463.3-520.8	511.6-565.8	559.9-623.0	318.8-396.0	468.2-566.1	526.1-615.6	621.3-735.0	384.6-505.6	592.5-732.5	644.6-768.1	761.8-915.1
Larynx	2.6-4.3	2.6-4.3	4.5-6.5	3.4-5.3	0.4-3.5	1.8-6.3	3.2-8.8	3.7-10.2	1.7	2.3-12.7	1.1-9.7	2.6-14.4	—	2.5-17.3	1.0-15.9	—
Stomach	7.8-10.6	7.9-10.7	6.8-9.2	6.3-8.8	8.9-18.1	7.7-17.3	5.4-12.2	9.1-18.4	15.8	17.8	11.5	15.0	11.9	7.3	9.6	22.2
Colon & Rectum	16.3	19.3	17.1	14.3	23.2	29.2	30.1	21.2	26.3	33.7	33.9	27.9	35.7	32.5	35.7	25.4
Liver	14.4-18.2	17.1-21.4	15.3-18.9	12.5-16.1	16.8-29.6	22.1-36.4	23.6-36.7	15.0-27.4	16.5-36.0	18.6-48.7	23.9-45.9	15.7-40.2	16.0-55.4	18.5-46.6	21.4-50.0	12.0-38.8
Pancreas	54.6	69.5	68.4	67.5	52.3	82.1	81.1	81.3	49.7	74.9	80.9	82.7	95.8	128.0	121.0	125.0
Lung & Pleura	51.0-58.1	65.6-73.5	64.8-72.0	63.6-71.3	42.3-62.3	70.7-93.4	70.6-91.7	69.5-93.1	34.6-64.8	56.6-93.2	64.0-97.8	62.7-103.0	64.1-128	98.6-157	95.7-147	95.6-154.0
Esophagus	3.3	4.7	4.1	6.1	5.0	4.9	5.3	7.0	4.3	6.8	3.7	6.6	4.9	7.7	8.0	11.5
Melanoma	2.4-4.1	3.6-5.7	3.2-5.0	4.9-7.2	2.5-7.6	2.3-7.5	2.6-8.1	3.7-10.3	0.5-8.1	1.7-12.0	—	1.3-11.9	—	1.5-14.5	1.5-14.5	2.9-20.0
Prostate	8.8	12.0	11.4	9.2	6.1	8.4	16.9	9.2	4.6	6.2	11.6	14.2	10.0	14.6	27.7	8.8
Kidney	7.4-10.3	10.4-13.6	9.9-12.8	7.8-10.6	3.1-9.2	5.0-11.9	12.0-21.7	5.3-13.0	0.5-8.7	1.6-10.7	5.3-17.9	6.5-22.0	0.3-19.7	5.3-23.9	15.4-40.0	1.1-16.4
Bladder	80.0	101.0	103.0	92.3	75.4	120.0	116.0	112.0	83.1	127.0	140.0	148.0	98.5	150.0	131.0	139.0
Breast	75.9-84.2	96.5-106.0	96.7-107.0	87.8-96.8	64.9-85.8	106.0-134.0	103.0-128.0	98.3-125.0	65.9-100.0	103.0-150.0	118.0-162.0	122.0-174.0	73.1-124.0	117.0-184	105.0-157.0	107.0-170.0
Brain	5.5	5.7	5.7	6.2	5.6	6.6	4.3	7.8	5.9	9.4	3.4	9.5	9.5	4.9	7.0	11.1
Hematopoietic	4.4-6.6	4.6-6.8	4.7-6.8	5.0-7.3	2.6-8.7	3.6-9.5	2.0-6.7	4.3-11.3	—	3.5-15.3	—	2.8-16.3	—	0.8-13.1	2.2-20.1	—
Lymph Nodes	6.3	9.7	12.6	13.5	2.5	7.8	10.2	14.9	2.5	7.5	7.9	12.7	1.0	11.0	19.4	21.6
Prostate	5.1-7.5	8.3-11.2	11.1-14.2	11.8-15.2	0.6-4.3	3.5-12.0	6.5-14.0	9.6-20.2	—	2.2-12.9	2.4-13.5	4.6-20.7	—	—	8.7-30.1	8.7-34.5
Kidney	54.2-61.7	79.5-88.5	102-110	114-124	41.7-61.8	61.9-84.7	94.4-119.0	143.0-175.0	36.2-67.7	65.1-106	84.8-123.0	143.0-200	36.3-85.0	72.3-126.0	118-173	195-274
Bladder	7.2-9.9	12.8-16.4	16.0-19.6	13.8-17.4	6.1-14.1	11.8-23.2	13.7-23.7	16.7-28.7	0.7-10.4	8.1-27.6	13.8-31.7	12.3-31.6	—	13.0-49.1	9.6-31.3	21.7-54.7
Breast	24.5-29.6	31.7-37.4	30.6-35.5	31.1-36.6	16.3-28.9	25.3-39.9	29.5-44.0	29.5-45.8	18.3-43.5	23.1-51.4	28.4-52.7	25.6-53.6	8.1-26.2	19.5-50.9	28.7-60.0	35.4-74.7
Brain	6.9	7.3	8.1	5.6	5.6	7.0	6.5	7.0	7.0	6.6	3.9	17.4	4.0	11.4	10.0	8.4
Hematopoietic	5.7-8.1	6.1-8.5	6.9-9.3	6.5-9.1	2.9-8.4	3.9-10.1	3.6-9.5	5.4-13.3	2.1-11.8	1.6-11.6	—	8.1-26.6	—	2.6-20.1	2.5-17.4	—
Lymph Nodes	8.0	9.9	12.0	10.3	4.0	9.7	11.7	12.8	5.7	6.3	16.4	7.3	6.0	20.8	15.0	14.5
Prostate	6.7-9.3	8.5-11.4	10.5-13.5	8.8-11.8	1.8-6.2	5.8-13.5	7.8-15.6	7.9-17.6	1.4-9.9	8.8-24.0	1.3-13.3	0.7-11.3	0.7-11.3	9.1-32.4	5.6-24.4	4.4-24.7
Lymph Nodes	19.0	22.0	24.1	26.0	16.1	20.2	25.3	22.0	14.4	15.6	27.6	23.1	26.1	33.1	36.9	37.5
Prostate	17.0-21.0	19.9-24.2	22.0-26.2	23.7-28.4	11.3-20.9	14.6-25.7	19.5-31.1	15.9-28.0	7.2-21.7	5.9-25.3	17.9-37.4	12.2-34.1	13.5-38.7	18.9-47.4	22.6-51.2	20.7-54.4

Nova Scotia rates based on data for which there are valid municipal residential information only (number missing = 646); Industrial Cape Breton County (excluding Sydney) is defined as the six communities surrounding Sydney Harbour excluding Sydney; * = rate is significantly higher than Nova Scotia rate for the same time period.

95% or greater from 1989 on. All NS cases lacking municipality of residence information were excluded from subsequent analyses.

We calculated gender-stratified, age-standardized cancer incidence rates with 95% confidence intervals¹⁴ following the direct method¹⁵ and using the 1991 Canadian population as a standard. All major cancer sites were included. Results are presented where the number of site-specific Sydney cases was observed to be five or more for the majority of the time intervals for the gender being considered.

The availability of postal codes from the 1989-1997 NS Cancer Registry records facilitated a sensitivity analysis of residential coding (municipality defined vs. postal code defined) from the most recent period. To reveal the agreement between both coding schemes, we calculated kappa statistics for the six ICB municipalities.¹⁶ Age-standardized incidence rates for the mutually exclusive geographic areas were calculated according to the direct method using the postal code-classified data and compared with the municipality-based rates.

Finally, a profile of the socio-economic characteristics of the CBCo demographic areas was generated after compiling municipality-based summary rates from 1991 Statistics Canada enumeration area data.¹⁷

RESULTS

All-cause rates

Municipality-coded all-cause age-adjusted incidence rates (presented in Tables IA and IB and in Figure 1) for Sydney female and male residents were significantly higher than comparable rates for NS females and males for all four time periods from 1979 to 1997. Postal code-based all-cause age-adjusted cancer incidence rates (Tables IIA and IIB; also Figure 1) for Sydney females (89-93 SIR = 1.10; 94-97 SIR = 1.21) and males (89-93 SIR = 1.19; 94-97 SIR = 1.19) were also significantly higher than for NS (slight overlap of 95% confidence intervals during 89-93 for women) for the most recent nine years.

Municipality-coded all-cause age-adjusted incidence rates for ICBxS female and male residents were significantly higher for the periods of 89-93 and 94-97, and addition-

Figure 1. Five-year all-cause cancer rates per 100,000, Nova Scotia and Cape Breton County Geographies

ally for 84-88 for ICBxS males but the rates were not higher for the earlier periods. Postal code-based all-cause age-adjusted cancer rates were significantly elevated for 94-97 for ICBxS women and men but, while both rates were higher for 89-93, the confidence intervals overlapped.

Both municipality-coded and postal code-based data indicate that all-cause age-adjusted cancer incidence rates were higher for CBCo females and males than rates for NS females and males during 1989 to 1997 (though 95% confidence intervals of 89-93 postal code-based data for women overlap). Elevated risks are not observed for the earlier periods as demonstrated by the municipality-coded data (though there is the suggestion of borderline significant elevation for males in 84-88).

Municipality-coded all-cause age-standardized incidence rates suggest that the Sydney rates were significantly higher

than rates for ICBxS and CBCo for all four time periods (Figure 1). On the contrary, the postal code-based data fail to demonstrate significant differences in the all-cause rates for either women or men between any of the CBCo geographies in the most recent two periods.

Sensitivity analysis of residential coding

With the exception of Sydney, the sensitivity analysis of municipality of residence information confirmed a high degree of consistency of the two residential coding systems: kappa statistics (all statistically significant) are as follows: Dominion 0.90, Glace Bay 0.99, New Waterford 0.94, North Sydney 0.93, Sydney 0.77, and Sydney Mines 0.99. With respect to Sydney, 315 of 1,147 cases classified as Sydney municipal residents were found to have postal codes in another location in the County. This observation is unique to

Sydney and is in contrast to the other ICBxS communities: only 6 of 70 for Dominion; 11 of 581 for Glace Bay; 24 of 237 for New Waterford; 30 of 266 for North Sydney; and 2 of 225 for Sydney Mines had inconsistent postal codes. Of the 315 discordant Sydney cases, 94% reported their municipality of residence as Sydney whereas their postal code classified them as living in the County (i.e., not in ICBxS). These cases have not, therefore, been misclassified to the other communities. Examination of the age-standardized incidence rate values (Tables IIA and IIB) for the two most recent periods reveals relative unanimity of the postal code-based rates with the municipal-coded rates for ICBxS, CBCo and NS. This reflects the consistency of residential coding noted above. In contrast, the postal code-based rates are lower than the municipality-coded rates for Sydney.

TABLE IIA
Age-Adjusted Incidence Rates and 95% Confidence Intervals per 100,000 – Females
Geographic Areas of Cape Breton County and Nova Scotia, 1979-1997 - Postal Code Data

Cancer Site	Nova Scotia		Cape Breton County		Industrial Cape Breton County minus Sydney		Sydney	
	89-93	94-97	89-93	94-97	89-93	94-97	89-93	94-97
All Causes	334.9	362.2	352.4	398.2 *	351.0	429.1 *	368.5	439.9 *
Stomach	327.7-342.0	354.2-370.3	332.9-371.9	375.5-420.8	319.8-382.1	390.9-467.2	328.5-408.5	388.8-491.1
Colon & Rectum	5.8	5.8	10.4 *	8.0	8.6	9.0	9.9	8.2
Pancreas	4.9-6.7	4.8-6.8	7.2-13.6	4.9-11.2	4.0-13.2	3.5-14.6	4.1-15.7	1.1-15.2
Lung and Pleura	47.6	48.2	45.4	47.8	50.4	50.3	44.7	58.2
Breast	44.9-50.2	45.4-51.0	38.6-52.2	40.3-55.3	38.9-61.8	38.0-62.5	31.7-57.7	41.4-74.9
Melanoma	7.1	8.4	7.2	7.2	6.4	7.9	7.0	4.8
Cervix	6.1-8.2	7.2-9.6	4.6-9.8	4.3-10.1	2.5-10.2	3.1-12.7	2.0-11.9	0.9-8.6
Corpus uteri	38.9	46.8	41.3	53.8	39.1	56.1	35.8	66.1
Ovary	36.4-41.3	43.9-49.7	34.6-48.0	45.5-62.1	28.7-49.6	42.2-70.0	23.5-48.0	47.0-85.3
Kidney	97.7	106.2	108.5	114.2	102.9	127.0	126.2 *	122.8
Bladder	93.8-101.6	101.9-110.6	97.6-119.4	102.0-126.3	85.9-120	106.3-147.6	102.4-150.1	95.1-150.6
Brain	10.6	10.8	5.7	13.0	4.0	10.0	5.2	14.7
Hematopoietic	9.3-11.9	9.4-12.3	3.1-8.3	8.6-17.4	0.4-7.5	3.8-16.2	0.3-10.1	5.3-24.2
Lymph Nodes	12.9	11.2	18.6	14.5	17.8	10.7	18.5	22.9
	11.4-14.3	9.7-12.7	13.8-23.4	9.8-19.2	10.0-25.5	4.3-17.2	8.8-28.2	9.4-36.5
	17.3	15.7	20.1	21.8	21.0	24.4	19.3	25.4
	15.7-19.0	14.0-17.5	15.5-24.7	16.6-27.1	13.6-28.4	15.6-33.2	10.5-28.0	13.4-37.5
	14.8	15.7	12.4	16.7	10.9	18.7	12.7	14.7
	13.3-16.4	14.0-17.5	8.8-16.1	11.9-21.5	5.5-16.4	10.3-27.1	5.7-19.7	5.2-24.1
	8.7	8.5	7.8	10.3	7.6	12.1	10.9	10.4
	7.6-9.9	7.3-9.8	4.9-10.7	6.7-13.9	3.0-12.2	5.4-18.8	4.1-17.8	3.6-17.2
	8.7	9.5	7.9	14.3	6.5	14.9	11.0	12.4
	7.5-9.8	8.3-10.8	5.0-10.8	10.0-18.5	2.3-10.7	7.7-22.2	3.7-18.2	4.7-20.1
	4.0	5.3	3.6	5.2	3.4	3.8	4.3	10.6
	3.2-4.8	4.3-6.3	1.5-5.6	2.5-7.9	—	0.4-7.2	—	1.2-20.0
	6.9	7.3	7.4	4.2	7.0	7.2	7.1	4.4
	5.9-7.9	6.1-8.4	4.5-10.3	1.8-6.6	2.5-11.5	1.9-12.6	1.1-13.2	—
	16.1	18.4	15.3	19.6	17.6	24.4	10.8	11.6
	14.5-17.7	16.6-20.3	11.2-19.5	14.4-24.8	10.7-24.5	14.6-34.2	3.8-17.8	3.3-19.9

Nova Scotia rates based on data for which there are valid postal-coded residential information only (number missing = 521); Industrial Cape Breton County (excluding Sydney) is defined as the six communities surrounding Sydney Harbour excluding Sydney; * = rate is significantly higher than Nova Scotia rate for the same time period.

Cancer site-specific rates

Rates of cancer of the breast and cervix were significantly higher for Sydney women than rates for NS women for all four time periods (with the exception of cervical cancer during 84-88), based upon the municipality-coded data. Sydney women were at increased risk for cancers of the breast (94-97 SIR = 1.21) and cervix (94-97 SIR = 2.04) using postal code-based data. Postal code-based rates of cancers of the stomach (94-97 SIR = 1.41), lung and pleura (94-97 SIR = 1.41), bladder (94-97 SIR = 1.30), brain (94-97 SIR = 2.0) are elevated but not significantly for Sydney women compared to NS women. Confidence intervals were broad due to small numbers of site-specific cases. These findings are contrary to the municipal data where statistically significant relationships may be observed for these cancer sites. Postal code-based rates, in addition to municipality-based rates, are generally higher for Sydney women than those for NS despite this lack of significance. Other cancer site-specific rates were

not statistically significantly different for Sydney women compared to NS women (both municipality-coded and postal code-based rates).

Postal code-based rates of cancer of the colon and rectum (89-93 SIR = 1.43) and prostate (94-97 SIR = 1.37) for Sydney males were significantly higher than rates for NS males. The municipality-coded data generated significant SIRs for these sites: colon and rectum (89-93 SIR = 1.77), prostate (94-97 SIR = 1.97), lung and pleura (94-97 SIR = 1.51), and kidney (94-97 SIR = 2.45). Similarly, sites noted to have elevated but not significant SIRs (according to the postal code-based rates) include: pharynx (94-97 SIR = 1.65), larynx (94-97 SIR = 2.13), stomach (89-93 SIR = 1.72), and kidney (94-97 SIR = 1.85). The remaining cancer site-specific postal code-based and municipality-based rates did not show significant differences between Sydney males and NS males.

ICBxS females were at increased risk for all-cause but none of the site-specific can-

cers compared to NS females (postal code data). ICBxS males were at increased risk for all-cause cancer and cancers of the stomach (89-93 SIR = 2.03), lung and pleura (94-97 SIR = 1.49) and prostate (94-97 SIR = 1.39) compared to NS males (postal code data).

When comparing CBCo females with NS females (postal code data), the rate of stomach cancer is significantly higher for CBCo women during 89-93 (SIR = 1.76) and also higher (SIR = 1.41) during 94-97 though this was not statistically significant. The SIR for stomach cancer for 89-93, based upon municipality-coded data, is 1.78 (significant) for women. Cancer rates of the larynx (94-97 SIR = 1.76), stomach (89-93 SIR = 1.80), lung and pleura (94-97 SIR = 1.20), and prostate (94-97 SIR = 1.33), based upon postal code rates, were significantly elevated for CBCo males compared to NS males. Similar SIR values can be observed when comparing the municipality-coded data [cancer rates of the larynx (94-97 SIR = 1.80), stomach

TABLE IIB
Age-Adjusted Incidence Rates and 95% Confidence Intervals per 100,000 – Males
Geographic Areas of Cape Breton County and Nova Scotia, 1979-1997 - Postal Code Data

Cancer Site	Nova Scotia		Cape Breton County		Industrial Cape Breton County minus Sydney		Sydney	
	89-93	94-97	89-93	94-97	89-93	94-97	89-93	94-97
All Causes	456.9 447.8-466.1	486.2 475.9-496.5	495.6 * 469.6-521.5	586.6 * 555.2-618.0	489.9 448.5-531.3	641.4 * 586.0-696.8	542.6 * 488.3-596.9	578.8 * 515.4-642.1
Pharynx	5.2 4.3-6.2	4.3 3.3-5.2	5.7 3.0-8.5	7.0 3.7-10.2	4.5 0.5-8.4	8.5 2.6-14.4	11.3 3.4-19.2	7.1 —
Larynx	7.5 6.3-8.7	7.6 6.3-8.8	8.5 5.1-11.8	13.4 8.8-18.0	9.9 4.0-15.7	12.9 5.6-20.2	6.0 —	16.2 5.6-26.8
Stomach	15.8 14.1-17.5	14.3 12.5-16.0	28.4 22.0-34.8	20.8 14.7-26.9	32.2 * 21.7-42.8	26.9 14.8-38.9	27.2 14.3-40.0	6.9 —
Colon & Rectum	64.9 61.5-68.4	67.6 63.7-71.4	75.3 65.2-85.5	80.5 68.8-92.3	68.0 52.5-83.5	79.6 59.9-99.3	92.5 * 70.2-114.8	94.1 69.0-119.2
Liver	3.5 2.7-4.3	6.2 5.0-7.4	4.3 1.8-6.7	7.4 4.0-10.8	3.7 —	6.6 1.3-11.9	5.5 —	8.3 0.9-15.6
Pancreas	10.0 8.6-11.3	9.4 8-10.8	12.7 8.5-16.9	9.2 5.3-13.0	8.1 2.8-13.5	14.2 6.5-22.0	17.5 7.9-27.2	3.7 —
Lung & Pleura	94.9 90.8-99.0	92.7 88.2-97.2	102.3 90.7-113.9	111.6 98.2-125.1	113.6 93.8-133.4	137.4 * 112.4-162.5	111.4 86.9-135.9	92.3 66.8-117.9
Esophagus	5.3 4.3-6.3	6.2 5.0-7.3	3.0 1.0-5.0	7.8 4.3-11.3	1.7 —	8.5 2.1-14.9	4.0 —	9.1 1.1-17.1
Melanoma	11.7 10.2-13.1	13.5 11.8-15.3	9.4 5.8-13.0	14.1 8.9-19.2	7.9 2.4-13.5	11.7 3.8-19.5	10.0 2.6-17.4	17.2 5.0-29.4
Prostate	101.8 97.4-106.2	118.7 113.6-123.9	105.9 93.9-118.0	158.0 * 141.7-174.4	100.3 81.6-118.9	164.6 * 136.6-192.6	118.2 93.5-142.9	162.2 * 129.3-195.1
Kidney	17.1 15.4-18.9	15.6 13.8-17.4	17.7 12.8-22.6	22.7 16.7-28.7	20.2 11.7-28.7	21.9 12.3-31.6	11.9 3.5-20.2	28.9 14.6-43.3
Bladder	31.1 28.7-33.5	33.7 31.0-36.5	34.1 27.2-41.0	36.8 28.8-44.9	38.6 26.8-50.4	37.1 23.5-50.6	34.2 20.7-47.8	37.0 21.0-53.0
Brain	7.7 6.5-8.8	7.9 6.6-9.2	6.5 3.6-9.5	9.3 5.4-13.3	3.9 —	17.4 8.1-26.6	2.8 —	6.5 —
Hematopoietic	10.1 8.7-11.4	10.5 9.0-12.0	8.4 5.1-11.7	12.8 7.9-17.6	10.7 4.6-16.9	7.3 1.3-13.3	13.9 4.7-23.1	7.0 —
Lymph Nodes	22.5 20.5-24.5	26.3 23.9-28.7	23.5 17.9-29.0	22.0 15.9-28.0	24.7 15.5-33.9	23.1 12.2-34.1	27.2 14.8-39.6	26.8 13.1-40.5

Nova Scotia rates based on data for which there are valid postal-coded residential information only (number missing = 521);

Industrial Cape Breton County (excluding Sydney) is defined as the six communities surrounding Sydney Harbour excluding Sydney;

* = rate is significantly higher than Nova Scotia rate for the same time period.

(89-93 SIR = 1.76), lung and pleura (94-97 SIR = 1.21), and prostate (94-97 SIR = 1.34) for CBCo males compared to NS males] to the postal-coded data. Other rates for both males and females, by either method of coding, were not significantly different between CBCo and NS.

Socio-demographic data

As presented in Table III, in 1991, Sydney, ICBxS and CBCo had older populations, lower labour force-participation rates and lower employment rates than NS.

DISCUSSION

This study provides scientific evidence that Sydney residents were at increased risk for all-cause cancer compared to NS during 1979-1997. Regardless of residence coding method, Sydney women were at increased risk for cancers of the breast and cervix, and Sydney men were at increased

TABLE III
Socioeconomic Characteristics of Sydney, Industrial Cape Breton minus Sydney (ICBxS), Cape Breton County (CBCo), and Nova Scotia (NS)*

	Sydney	ICBxS	CBCo	NS
Total population over 15 yrs	20,770	34,870	94,500	706,675
% Population greater than 65 years	16	15	13	12
% Population 15+ with less than grade 9	12	20	16	13
% Unemployment rate, both sexes, 15+	10	10	10	8
% in labour force, both sexes, 15+	54	47	53	63
% employed, both sexes, 15+	44	36	43	55

* Source: Statistics Canada, 1991 Population census. These data originate from the Statistics Canada CANSIM data base. CANSIM is an official Mark of Statistics Canada.

risk for cancers of the colon and rectum and prostate relative to NS women and men. Female and male residents of ICBxS and CBCo were also at higher risk for all-cause cancer when compared to NS overall.

The sensitivity analysis of residence classification yielded a high degree of consistency between municipality and postal code information from cancer registry records for ICB municipalities with the

exception of Sydney. According to postal code information, 27% of cases that were identified as Sydney residents by municipality were found to live in CBCo (i.e., not in the other ICBxS communities). Sydney has experienced the growth of several suburban areas in recent years. The discordant cases may have self reported that they lived in "Sydney" but actually live in these newly developed areas and commute to Sydney to shop and work. It is plausible, while the

postal-coded data likely provide more accurate geographically based estimates of cancer incidence, the municipality-coded rates for Sydney may portray more reliably the cluster of cases that have been regularly exposed to the Sydney environment. Information about individual residential histories and exposure profiles would help to clarify this issue. Regardless of whether the Sydney cases live within or outside the city boundaries, they remain residents of CBCo. The population of Sydney (25,768 in 1991) comprises about 25% of the County's population; the health experience of the community would significantly influence County-based rates.

CBCo all-cause cancer rates were higher than NS rates. Furthermore, while the values for Sydney rates varied by residence-coding method, ICBxS and CBCo rates and resulting SIR values remained relatively consistent. The time trends demonstrated in the NS, CBCo and ICBxS municipality-coded data thus provide insights into the cancer experience for these geographies spanning twenty years, but less so for Sydney. Most striking are the consistently elevated rates for cancers of the stomach, breast and cervix for CBCo women and stomach, lung and prostate for CBCo men.

These research findings are in agreement with our observation that Sydney women and men are at risk for excess life loss due to cancer compared to Canadian women and men.⁷ These results are also consistent with other studies noting increased cancer mortality rates in Sydney and CBCo^{8,9} and a recent British study noting increased cancer mortality in communities living within 5 kilometres of coke ovens.¹⁸ Studies of occupational exposures to coke ovens and steel mills have consistently documented the increased risk for certain forms of cancer¹⁹⁻²⁴ also elevated in this study. The fact that rates for both women and men were increased in this study suggests, however, that these findings are not principally explained by occupational factors. A population-based study of 1,300 Sydney residents conducted in 1995 demonstrated the prevalence of current smokers to be 31%,²⁵ this is only slightly higher than the overall provincial prevalence of 29%²⁶ at the time. Other studies have shown that

CBCo residents are more likely to smoke,^{27,28} to have poorer diets,^{27,28} and to have less access to cancer screening programs²⁹ than others in Canada. This may be a reflection of general conditions in NS, given that NS has among the highest provincial cancer rates in Canada,³⁰ and that the NS cancer rates are noticeably higher than those recently reported for Canada as a whole.³¹ Furthermore, as shown in Table III, CBCo residents are less well educated and more likely to be unemployed – two additional factors known to be associated with increased cancer rates.³² Breast cancer, while often linked with higher socio-economic status, also has a multifactorial etiology and other factors may explain the increased risks observed in this study.

Recent and accurate diagnostic data contained within the NS Cancer Registry records, supplemented by the fact that cancer is a reportable disease in NS, were used to conduct this study. Geographic boundaries for both numerators and denominators were identical. Standard epidemiological methods were used for ease of data interpretation, yet more sophisticated approaches might facilitate assessment of specific cancer trends, especially given the variation introduced by small numbers.

Evidence that exposures to carcinogens found in Sydney's ambient environment may have contributed to increased cancer risk in CBCo is supported by the pattern of cancer site-specific risks that are increased in this study. PAHs and PAH-containing substances have been associated with an increased risk for lung, stomach, colo-rectal, bladder, prostate and breast cancer;³³ arsenic is a lung carcinogen when inhaled³⁴ and a bladder carcinogen when ingested.³⁴ Other possible explanations for the increased risk noted for Sydney include the presence of several senior citizens residences, the occupants of which may have chosen to live in Sydney or ICBxS due to deteriorating health or the possibility of systematic bias introduced by differences in diagnostic procedures in the region. Our recent analysis of selective outward migration failed to fully explain the significant excess loss of life expectancy we observed for CBCo,³⁵ but these other factors have not been studied.

In summary, the results of this ecological study support the need for further analysis of the underlying factors contributing to the increased risk for cancer in CBCo. Ecological studies provide the initial step in examining questions of risk but do little to elucidate individual-level patterns of exposure leading to these outcomes.

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