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Geographic variation in female breast cancer incidence and mortality in Canada

by Rochelle Garner and John Than

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ABSTRACT

Background

Previous work has noted variability in cancer incidence and cancer-related outcomes according to place of residence. This study examined geographic variability in the incidence and mortality of breast cancer among females in Canada.

Data and methods

Data from the 2021 Canadian Cancer Registry (breast cancer incidence) and the Canadian Vital Statistics – Death database (breast cancer mortality) were examined across provinces and territories, community sizes, and peer groups (i.e., clusters of health regions with similar socioeconomic and demographic characteristics). Age-standardized incidence rates (ASIRs) and age-standardized mortality rates (ASMRs) per 100,000 females per year and their rate ratios were calculated, as well as age group-specific and age-standardized stage-specific incidence rates.

Results

From 2010 to 2020, the invasive breast cancer ASIR was 140.1 per 100,000 females annually, with marked geographic and community variation. Mean age at diagnosis was 62.7 years, and it was lowest in northern and remote regions. Three-quarters of cases were stages I and II, though stage-specific ASIRs varied. Overall ASIRs were highest in peer groups B (urban centres with large immigrant and racialized populations) and D (rural regions in Quebec, Ontario and the Prairies). They were lowest in peer groups F (Northern and remote regions with young populations), G (Montréal, Toronto, and Vancouver), and H (urban centres in Ontario and British Columbia). From 2010 to 2022, the ASMR was 28.3 per 100,000, highest in rural Eastern Peer Group E and lowest in large urban centres.

Interpretation

The study found significant variability in female breast cancer incidence and mortality across the geographical classifications considered, highlighting the need for a closer look at regional- and individual-level factors and their respective associations with cancer incidence and outcomes.

Keywords

breast cancer, geographic variation, incidence, mortality, cancer registry, vital statistics

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What is already known on this subject?

- Breast cancer is the most commonly diagnosed cancer and the second most common cause of cancer-related deaths among females in Canada.
- Previous research has shown associations between a person's place of residence and their risk of certain health conditions and outcomes, including their risk of breast cancer.
- Breast cancer screening participation and receipt of certain treatments after diagnosis have also been shown to vary regionally in Canada.

What does this study add?

- Age-standardized breast cancer incidence and mortality rates showed significant geographic variability, as did characteristics such as age and stage at diagnosis.
- Different classifications of geography—such as province or territory of residence, population size of the community, or the socioeconomic and demographic characteristics of the health region of residence—yield different patterns of breast cancer incidence and mortality rates.
- Geographic patterns for incidence rates are not necessarily the same when examining mortality-related outcomes. For example, regions with relatively higher breast cancer incidence rates do not necessarily also experience relatively higher breast cancer mortality rates.

Breast cancer is the most commonly diagnosed cancer among females in Canada,¹ with 30,500 females estimated to be diagnosed with breast cancer in 2024 and 5,500 females dying of breast cancer in that same year.² While breast cancer incidence³ and mortality⁴ have decreased over the last decade, national-level estimates mask underlying variability, including variability by age, socioeconomic characteristics, and geography.

Previous work has noted variability in cancer incidence and outcomes according to where an individual lives.⁵ Lagacé et al. (2019) found that breast cancer incidence was highest in cities and neighbourhoods with older female populations and with higher proportions of non-racialized individuals.⁶ After diagnosis, Huang et al. (2024) found that post-mastectomy breast reconstruction rates were significantly lower in rural regions of Alberta compared with urban regions of the province.⁷ Similarly, work by Carrière et al. (2018) found jurisdictional variability in surgical intervention following a breast cancer diagnosis.⁸

Preventive screening is recommended to detect breast cancer earlier, thereby improving a woman's chance of survival and her quality of life with the disease.⁹ While all Canadian provinces and territories, except Nunavut, have organized breast cancer screening programs, these differ in age of eligibility, screening modalities, and abnormal mammogram follow-up procedures.¹⁰ Similarly, participation in screening programs varies jurisdictionally, as do diagnostic wait times and other screening program quality measures.^{11,12} Although screening does not change the underlying disease, it can result

in higher reported incidence because more cases, especially small or slow-growing tumours, are found. As such, programmatic and participation differences in screening could yield differences in breast cancer rates.

In addition to such system-level differences, other factors known to be associated with breast cancer risk have also been shown to vary geographically. For example, alcohol consumption, a known breast cancer risk factor,¹³⁻¹⁵ has been shown to vary across provinces,¹⁶ with alcohol-related harms being higher in rural rather than urban regions.^{16,17} Similarly, smoking patterns vary significantly by province, with rates typically being higher in Quebec and the Atlantic provinces than elsewhere.¹⁸ Genetic variants may also be more prevalent in some regional communities than others because of significant founder effects.¹⁹⁻²²

The present study examined geographic variability in breast cancer incidence and mortality among females in Canada. Drawing upon a range of data sources, this study characterized residential location according to a variety of factors, with the objective of highlighting where geography is associated with disparities in breast cancer incidence and outcomes.

Data and methods

This study used the Canadian Cancer Registry (CCR) to examine the incidence of breast cancer among females in Canada, as well as age and stage at diagnosis, and the Canadian Vital Statistics – Death (CVSD) database to examine breast cancer mortality among females.

Table 1

Description of socioeconomic and demographic characteristics of health region peer groups, 2018 classification

Peer group and short descriptor	Population density	Proportion of racialized population	Proportion of population younger than 20	Long-term unemployment rate	Five-year internal migration
A: Rural and remote regions in the Western provinces and the territories	Very low	High	Very high	High	High
B: Urban centres with high employment and large immigrant and racialized populations	High	High	Medium	Low	Low
C: Sparsely populated urban and rural mix from coast to coast with a large population of seniors (i.e., aged 65 and older)	Medium	Medium	Low	Medium	Medium
D: Rural regions in Quebec, Ontario, and the Prairies	Medium	Medium	Medium	Low	High
E: Rural Eastern regions with a very large population of seniors (i.e., aged 65 and older)	Medium	Very low	Very low	Very high	Low
F: Northern and remote regions with a large population of children and youth (i.e., younger than 20)	Very low	Very low	Very high	Very high	Low
G: Montréal, Toronto, and Vancouver	Very high	Very high	Low	Medium	Very low
H: Urban centres in Ontario and British Columbia with very high dwelling values	Very high	Very high	Medium	Low	Medium

Source: Adapted from Table 5.3.1 and Appendix C in Statistics Canada (2018).

2021 Canadian Cancer Registry

The CCR is a national, population-based registry of cancers diagnosed among Canadian residents since 1992. The present study identified all primary cases of invasive breast cancer (using Surveillance, Epidemiology, and End Results site rules, version 2008) diagnosed in females (based on sex at birth) from January 1, 2010, to December 31, 2020. Records were excluded if they were staged as in situ breast cancer cases (i.e., Stage 0) or were not the first primary breast cancer during the observation period; a final sample of 255,680 individuals was retained for analysis. In sub-provincial and sub-territorial analyses, only cases with valid residential postal codes (i.e., postal code exists and was not associated with a post-office or non-residential buildings) were included (n=243,915).

In the 2021 CCR, cancer cases were unavailable for Quebec residents after 2017 and for Nova Scotia residents after 2019. Additionally, analyses that consider the stage at diagnosis exclude Quebec, because that information was unavailable over the full study period. Furthermore, stage-specific analyses included data for a particular province or territory in a given year only if at least two-thirds of the cases were staged. This resulted in the exclusion of records from Nova Scotia (2019), New Brunswick (2018 to 2019), Saskatchewan (2018), and Nunavut (2010 to 2020).

Canadian Vital Statistics – Death database

The CVSD is an administrative database that collects demographic and cause of death information from all provincial and territorial vital statistics registries on all deaths in Canada. For the present study, all deaths attributable to breast cancer (i.e., where the primary cause of death was coded with International Statistical Classification of Diseases and Related Health Problems, 10th Revision codes C50.*) among females (based on sex at birth) from January 1, 2010, to December 31, 2022, were included. Deaths for years 2019 through 2022 are considered preliminary in the CVSD. Additionally, Yukon deaths were not available for 2017 onwards.

Geographic classifications

This study used three geographic classifications: (1) province or territory, (2) community size, and (3) health region peer group. Province or territory is defined as the province or territory of usual residence at the time of cancer diagnosis (CCR) or death (CVSD). Using the Postal Code^{OM} Conversion File Plus

(PCCF+) software, version 7E,²³ community size and health region peer groups were assigned according to the postal code of patients' usual place of residence. Community size, defined in terms of the 2016 Census population in each census metropolitan area (CMA) or census agglomeration (CA), was classified as: (1) 1,500,000 or more, (2) 500,000 to 1,499,999, (3) 100,000 to 499,999, (4) 10,000 to 99,999 (any CMA or CA less than 100,000), and (5) less than 10,000 (any non-CMA or non-CA).

Health regions are legislated administrative areas defined by provincial ministries of health and represent geographic areas of responsibility for hospital boards or regional health authorities. Statistics Canada used a clustering technique to group health regions with similar socioeconomic characteristics into peer groups. The PCCF+ was used to assign patients' postal codes to health regions, which were subsequently mapped to the 2018 classification of peer groups (i.e., eight groups, A through H).²⁴ Key socioeconomic and demographic characteristics defining the peer groups are summarized in Table 1.

Statistical analysis

Age was categorized as younger than 40, 40 to 49, 50 to 59, 60 to 69, 70 to 79, and 80 or older. Stage at diagnosis was classified as I, II, III, IV, or unstaged. Staging was based on the American Joint Committee on Cancer (AJCC) version 7 for diagnoses from 2010 to 2017, and AJCC version 8 clinical staging thereafter.

Population counts of females (or women+) for relevant geographies (i.e., Canada; the provinces and territories;²⁵ CMAs, CAs, and areas outside CMAs and CAs;²⁶ and health regions²⁷) were used in the denominator for incidence and mortality rate calculations. Population data were included according to the availability of the incidence or mortality data. For example, population counts for incidence rate calculations excluded geographies within Quebec from 2018 to 2020 and geographies within Nova Scotia in 2020.

Incidence and mortality rates and their 95% confidence intervals (CIs) were calculated per 100,000 females per year and were age-standardized to the 2016 female population of Canada.²⁵ Incidence rates were additionally examined by age group (crude rates) and stage at diagnosis (age-standardized rates). Rate ratios (RRs) and their 95% CIs were calculated relative to a reference group. Geographies whose RR 95% CIs did not contain the value of 1.0 were considered statistically significantly different from the reference category (0.05

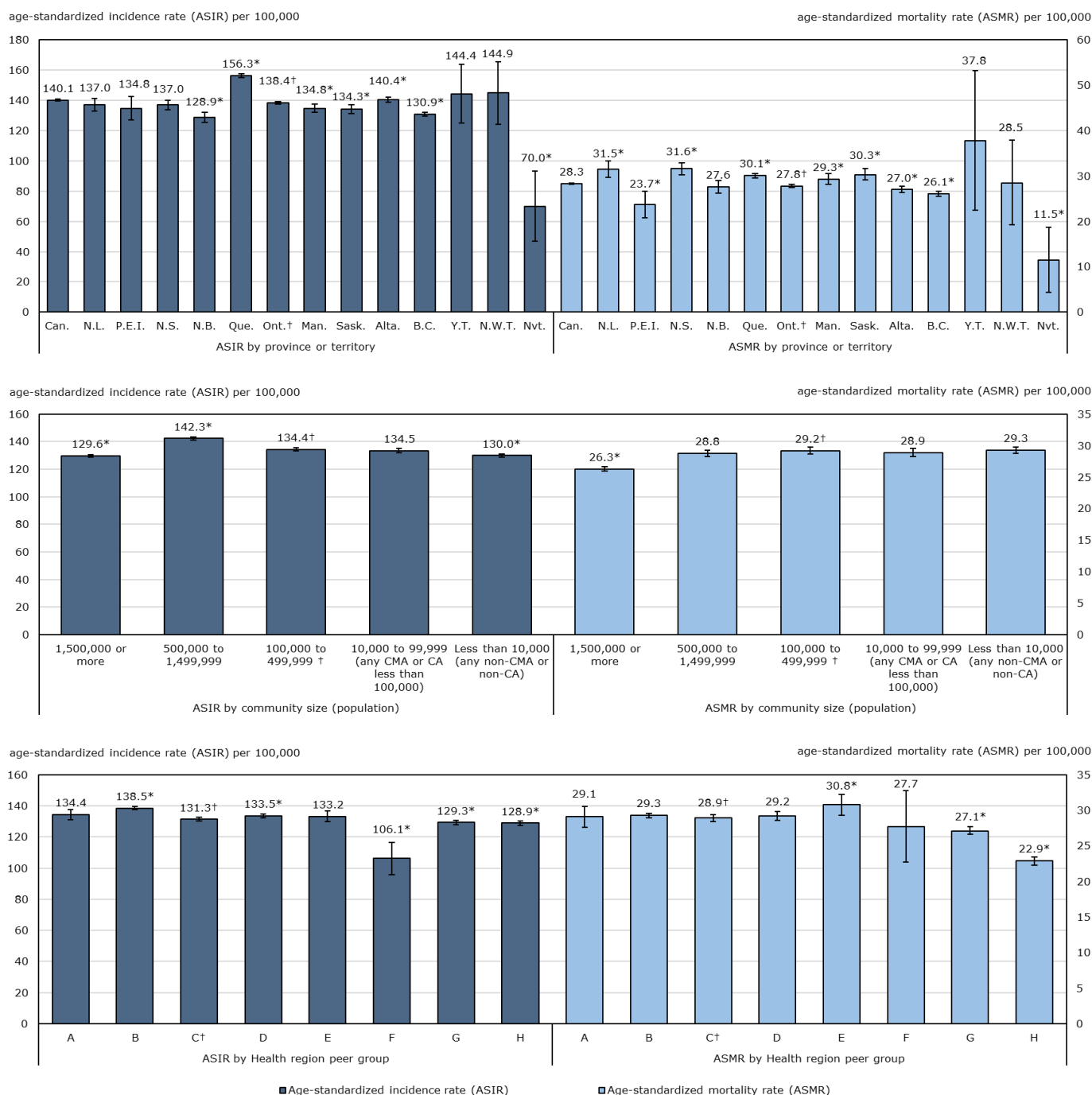
significance level). Reference categories were selected either because they were the most populous (e.g., Ontario) or because they had representation across the county (e.g., Peer Group C or mid-sized communities).

Mean age at diagnosis was compared between geographic regions using ANOVA (0.05 significance level), with pairwise

tests adjusted using Dunnett's method. Stage at diagnosis was compared across age groups with females diagnosed in their 50s using t-tests with Bonferroni adjustment (0.05/5=0.01 significance level). Analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, North Carolina) and SAS-callable SUDAAN v11.

Chart 1

Age-standardized incidence rates of invasive breast cancer among females (2010 to 2020) and female breast cancer mortality rates (2010 to 2022), rates per 100,000 females, nationally and by geographic region



* statistically significantly different from the reference category ($p < 0.05$) based on the rate ratios and their confidence intervals
† reference category for comparisons

Notes: CMA = census metropolitan area; CA = census agglomeration. Rates were age standardized to the female population as per population estimates on July 1, 2016. Incidence data were available only from 2010 to 2017 for Quebec and from 2010 to 2019 for Nova Scotia. Yukon mortality data were available only from 2010 to 2016.

Sources: Canadian Cancer Registry, 2021 diagnosis year; and Canadian Vital Statistics - Death database, 2010 to 2022.

Results

Breast cancer incidence from 2010 to 2020

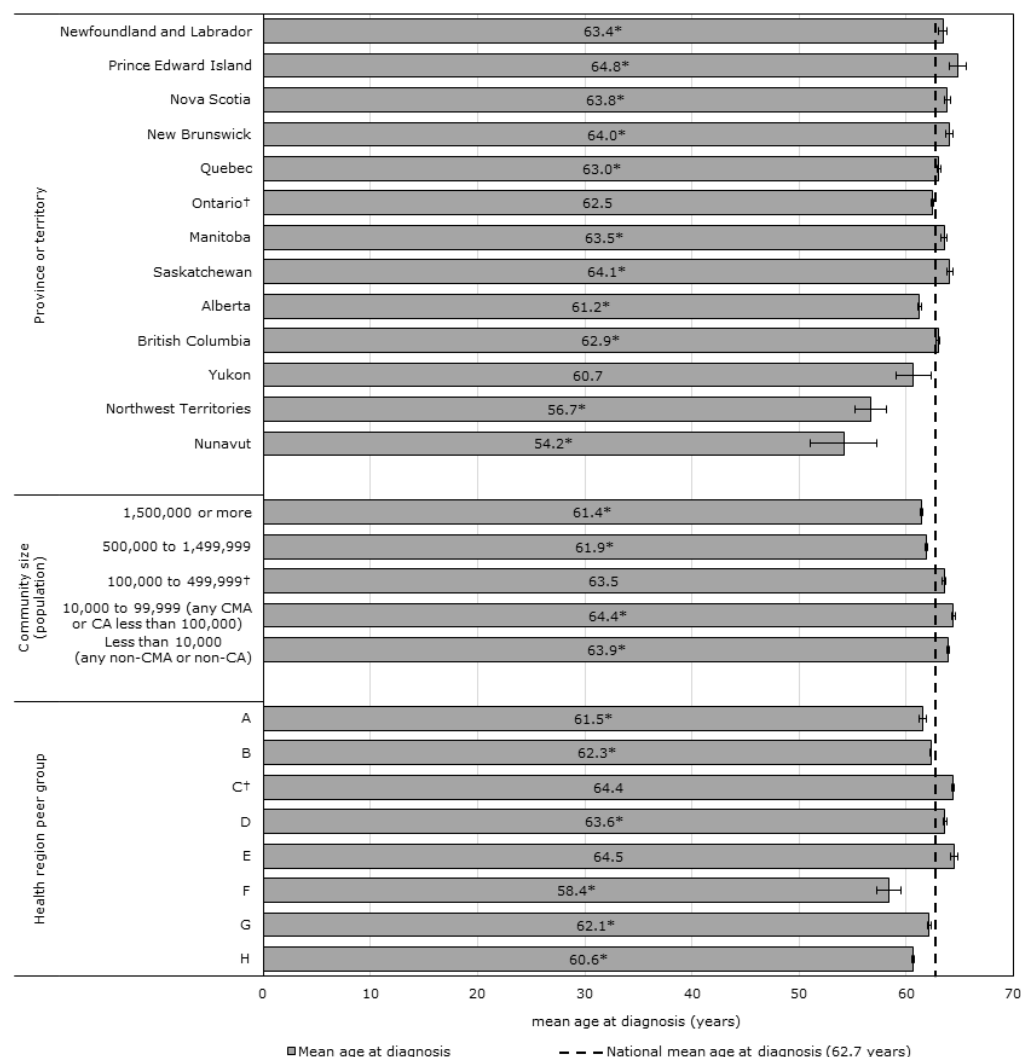
From 2010 to 2020, the age-standardized incidence rate (ASIR) of invasive breast cancer was 140.1 per 100,000 females per year (Appendix Table A). ASIRs varied across provinces and territories; they were significantly higher in Quebec and Alberta, and significantly lower in New Brunswick, Manitoba, Saskatchewan, British Columbia, and Nunavut, compared with Ontario (Chart 1, upper panel).

Communities with a population of 1,500,000 or more (129.6 per 100,000) and small non-CMA or non-CA communities (130.0 per 100,000) had significantly lower ASIRs than communities with 100,000 to 499,999 residents (134.4 per 100,000). Conversely, females in communities with 500,000 to 1,499,999

residents had a significantly higher ASIR (142.3 per 100,000; Chart 1, middle panel) compared with the reference group.

Compared with Peer Group C (131.3 per 100,000)—the reference group, composed of a mix of urban and rural communities from coast to coast with a large population of seniors (i.e., aged 65 and older)—two peer groups had statistically significantly higher ASIRs: peer groups B and D (Chart 1, bottom panel). Peer Group B (138.5 per 100,000) includes primarily urban centres with high rates of employment and high proportions of immigrant and racialized residents, while Peer Group D (133.5 per 100,000) includes primarily rural regions in Quebec, Ontario and the Prairies. By contrast, statistically significantly lower ASIRs were found for Peer Group F (106.1 per 100,000), Peer Group G (129.3 per 100,000), and Peer Group H (128.9 per 100,000; Chart 1, bottom panel). Whereas Peer Group F is composed of Northern

Chart 2
Mean age at diagnosis of invasive breast cancer cases among females (2010–2020), nationally and by geographic region



* statistically significantly different from geographic reference based on the ANOVA (test of equality of means at the 0.05 significance level and subsequent pairwise tests against the reference group using Dunnett's method)

† reference category

Notes: CMA = census metropolitan area; CA = census agglomeration. Incidence data are available only from 2010 to 2017 for Quebec and from 2010 to 2019 for Nova Scotia.

Source: Canadian Cancer Registry, 2021 diagnosis year.

and remote regions with relatively younger populations, peer groups G and H are densely populated urban centres. Although the RRs for peer groups G and H are statistically significantly different from 1.0, their values approach those of non-significance, whereas the ASIR for Peer Group F is well below that of the reference group (Appendix Table A).

Age at diagnosis

Nationally, the mean age at diagnosis of invasive breast cancer was 62.7 years, varying significantly across the country (Chart 2). Mean age at diagnosis was significantly lower in Nunavut (54.2), the Northwest Territories (56.7), and Alberta (61.2) compared with Ontario (62.5); other provinces had significantly higher mean ages at diagnosis (Chart 2).

In general, the mean age at diagnosis increased with decreasing community size (Chart 2). Across peer groups, Peer Group F—i.e., Northern and remote regions with younger populations—had the lowest mean age at diagnosis (58.4 years), while the highest mean ages at diagnosis were found in peer groups C (64.4) and E (64.5; Chart 2). Both these peer groups have a high proportion of seniors, although Peer Group E communities tend

to be in rural Eastern regions, while Peer Group C regions are found across the country. All other peer groups had significantly lower mean ages at diagnosis (Chart 2).

While age group-specific incidence rates largely mirrored ASIR patterns, there were some notable exceptions. For example, whereas the overall ASIR was higher in Alberta than in Ontario (Chart 1, upper panel), age group-specific incidence rates were only higher in Alberta for females in their 60s and 70s. Conversely, incidence rates for younger age groups were significantly lower in Alberta compared with Ontario (Table 2). Likewise, whereas the overall ASIR in the largest communities (i.e., population of 1,500,000 or more) was significantly lower than that in mid-sized communities (i.e., population from 100,000 to 499,999; Chart 1, middle panel), age group-specific incidence rates were significantly higher for young females (i.e., females younger than 50) in the former than the latter (Table 2). This pattern is also seen in peer groups G (i.e., Montréal, Toronto, and Vancouver) and H (i.e., other urban centres in Ontario and British Columbia), where overall ASIRs were lower than the reference group, but incidence among females younger than 50 was actually significantly higher (Table 2). Age group-specific incidence only becomes

Table 2

Crude incidence rate of invasive breast cancer cases among females (2010 to 2020),¹ by age group, nationally and by geographic region

Geography	Younger than 40 years			40 to 49 years			50 to 59 years			60 to 69 years			70 to 79 years			80 years and older		
	Incidence rate	95% confidence interval from	to	Incidence rate	95% confidence interval from	to	Incidence rate	95% confidence interval from	to	Incidence rate	95% confidence interval from	to	Incidence rate	95% confidence interval from	to	Incidence rate	95% confidence interval from	to
National	12.8	12.5	13.0	137.5	136.0	138.9	220.3	218.6	222.1	324.4	322.0	326.8	375.5	372.2	378.8	347.0	343.2	350.8
Province or territory²																		
Newfoundland and Labrador	13.0	11.0	15.0	123.4 *	112.8	133.9	200.4 *	187.7	213.2	323.6	306.5	340.7	389.2	364.3	414.2	365.6	333.3	397.8
Prince Edward Island	10.7	7.4	14.1	116.4 *	96.4	136.4	184.4 *	160.8	208.0	324.0	290.5	357.5	405.7	357.3	454.1	384.9	327.0	442.7
Nova Scotia	12.2	10.7	13.7	136.8	127.9	145.7	196.5 *	186.7	206.4	325.3	311.4	339.1	372.0	353.0	391.1	362.6 *	339.8	385.4
New Brunswick	11.6	10.1	13.2	116.6 *	107.9	125.4	195.9 *	185.3	206.4	297.5 *	283.6	311.4	357.4	337.6	377.1	349.9	326.2	373.6
Quebec	14.3 *	13.7	14.9	148.5 *	144.9	152.2	256.5 *	252.1	261.0	372.9 *	366.9	378.9	385.0 *	377.2	392.7	388.6 *	379.4	397.7
Ontario [†]	13.1	12.8	13.5	140.5	138.3	142.8	220.0	217.3	222.7	314.2	310.4	317.9	366.2	361.1	371.2	338.9	333.1	344.7
Manitoba	10.1 *	9.1	11.2	123.4 *	116.2	130.6	208.6 *	199.4	217.7	318.7	306.0	331.4	383.7	365.8	401.6	339.6	320.8	358.4
Saskatchewan	10.7 *	9.5	11.8	120.1 *	112.2	128.0	202.3 *	192.5	212.0	315.0	301.2	328.8	394.0 *	374.3	413.6	346.5	326.7	366.3
Alberta	12.4 *	11.7	13.0	133.0 *	128.9	137.1	213.5 *	208.3	218.8	328.9 *	321.1	336.6	410.0 *	398.4	421.6	329.0	316.5	341.5
British Columbia	12.0 *	11.4	12.6	132.5 *	128.8	136.2	200.2 *	195.8	204.6	298.4 *	292.4	304.3	364.8	356.4	373.3	321.2 *	311.6	330.7
Yukon	9.4	3.6	15.2	94.9 *	61.0	128.9	224.6	173.8	275.4	337.6	261.2	414.0	404.7	270.6	538.7	505.2	283.8	726.6
Northwest Territories	10.6	5.2	15.9	144.2	124.0	184.2	260.3	205.0	315.6	323.6	238.1	409.1	298.3	167.6	429.0	490.8	242.4	739.2
Community size (population)																		
1,500,000 or more	12.9 *	12.5	13.3	137.9 *	135.5	140.2	207.9	205.0	210.9	294.2 *	290.1	298.3	330.9 *	325.4	336.5	307.3 *	301.0	313.6
500,000 to 1,499,999	13.1 *	12.6	13.6	138.6 *	135.3	141.8	224.9 *	220.8	229.0	330.1 *	324.3	335.9	387.4	379.2	395.5	340.2	331.3	349.1
100,000 to 499,999 [†]	11.9	11.4	12.4	126.5	123.2	129.8	208.5	204.5	212.5	311.1	305.7	316.6	377.0	369.4	384.5	334.4	326.1	342.6
10,000 to 99,999																		
(any CMA or CA less than 100,000)	11.4	10.7	12.1	118.2 *	113.9	122.5	207.1	201.9	212.3	319.1	312.1	326.0	369.8	360.4	379.2	337.1	326.6	347.6
Less than 10,000																		
(any non-CMA or non-CA)	10.0 *	9.4	10.5	116.7 *	113.2	120.1	201.6 *	197.6	205.6	309.9	304.6	315.2	359.8 *	352.3	367.3	338.0	329.0	347.1
Health region peer group																		
A: Rural and remote regions in the Western provinces and the territories	10.0	8.9	11.1	121.8	114.2	129.4	202.9	193.2	212.6	324.9 *	310.3	339.6	397.4 *	375.6	419.2	320.2	296.1	344.4
B: Urban centres with high employment and large immigrant and racialized populations	12.7 *	12.4	13.1	134.5 *	132.1	136.9	215.6 *	212.6	218.7	322.2 *	318.0	326.5	378.6 *	372.6	384.5	337.7	331.1	344.2
C: Sparsely populated urban and rural mix from coast to coast with a large population of seniors (i.e., aged 65 and older) [†]	11.0	10.5	11.6	120.0	116.7	123.3	205.4	201.6	209.2	308.6	303.6	313.6	362.9	356.1	369.8	333.1	325.3	341.0
D: Rural regions in Quebec, Ontario, and the Prairies	11.2	10.6	11.8	119.8	116.0	123.7	209.4	204.8	214.1	316.0	309.7	322.4	365.7	357.0	374.5	342.1	331.9	352.3
E: Rural Eastern regions with a very large population of seniors (i.e., aged 65 and older)	12.0	10.2	13.9	114.1	104.6	123.5	202.7	191.4	213.9	311.0	296.2	325.7	369.0	348.2	389.7	368.9 *	342.8	395.0
F: Northern and remote regions with a large population of children and youth (i.e., younger than 20)	4.7 *	3.0	6.4	85.5 *	67.9	103.2	165.0 *	138.2	191.9	294.8	247.6	341.9	265.4 *	198.2	332.6	261.4	158.9	363.9
G: Montréal, Toronto, and Vancouver	13.1 *	12.5	13.7	140.7 *	136.9	144.5	211.1	206.4	215.9	289.5 *	283.2	295.8	324.4 *	316.2	332.6	302.3 *	293.6	311.0
H: Urban centres in Ontario and British Columbia with very high dwelling values	12.9 *	12.2	13.5	139.4 *	135.7	143.2	206.2	201.6	210.9	291.5 *	285.0	298.0	331.2 *	322.1	340.3	299.5 *	288.6	310.3

* associated rate ratio (not shown) is statistically significantly different from 1.0 ($p < 0.05$)

[†] Reference category for statistical comparisons

1. Incidence data are available only from 2010 to 2017 for Quebec and from 2010 to 2019 for Nova Scotia.

2. Because of small case counts resulting in high variability in estimates, the rates for Nunavut are suppressed.

Notes: CMA = census metropolitan area; CA = census agglomeration.

Source: Canadian Cancer Registry, 2021 diagnosis year.

significantly lower than the reference group for peer groups G and H among females aged 60 and older.

Stage at diagnosis and stage-specific incidence rates

Over the study period, 74.9% of invasive breast cancers were diagnosed at Stage I or II; 5.2% of cases were diagnosed at Stage IV, while 9.7% of examined cancers were unstaged (Chart 3). Invasive breast cancers diagnosed among females younger than 40 were most often diagnosed at Stage II (38.4%), while females diagnosed at 40 or older were more commonly diagnosed at Stage I (Chart 3). Conversely, females diagnosed before age 40 or after age 69 were significantly more likely than those diagnosed in their 50s to be diagnosed at Stage IV. The prevalence of unstaged cancers was higher among females diagnosed at age 70 or older or before the age of 50 compared with those diagnosed in their 50s (Chart 3).

Compared with ASIRs in Ontario, some Atlantic provinces had significantly higher Stage I (i.e., Newfoundland and Labrador and Prince Edward Island) and Stage IV (i.e., Newfoundland and Labrador, Nova Scotia, and New Brunswick; Table 3) ASIRs, even though these provinces had similar or lower overall ASIRs than Ontario (Chart 1, upper panel). Stage IV ASIRs were also significantly higher in Manitoba, Saskatchewan, and Alberta compared with Ontario (Table 3). Most provinces and territories had similar Stage III ASIRs as Ontario, except for Nova Scotia and British Columbia, where Stage III ASIRs were significantly lower (Table 3). Unstaged ASIRs were similarly high in Ontario, Nova Scotia, Yukon, and the Northwest Territories, but significantly lower in other provinces (Table 3).

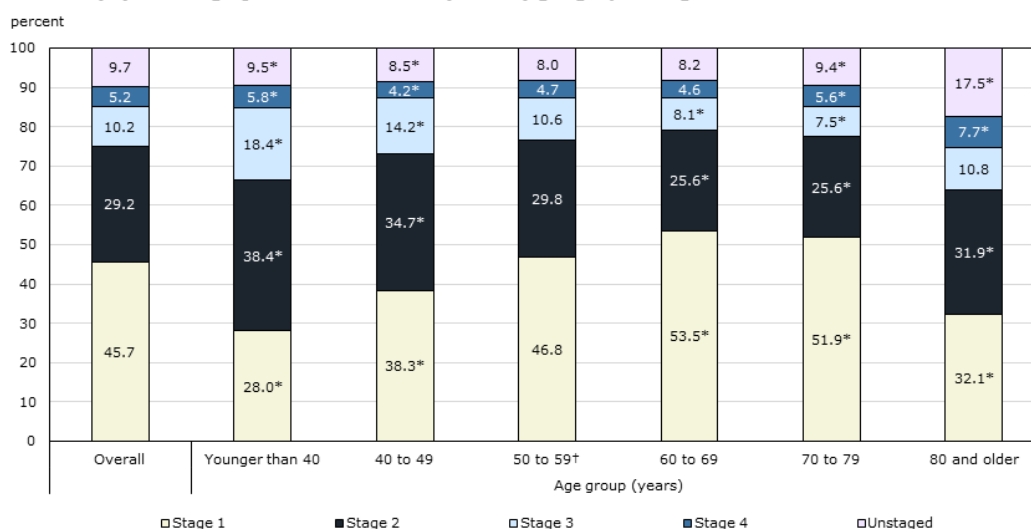
Across community sizes, variability in stage-specific ASIRs was largely restricted to early-stage rates (i.e., stages I and II). For communities under 1,500,000 residents, Stage I and II ASIRs tended to increase with population size, while Stage III and IV ASIRs were relatively stable. The largest communities deviated from this trend. Compared with communities with populations from 100,000 to 499,999, those with 1,500,000 residents or more had significantly lower ASIRs for all stages, except for Stage III (Table 3), consistent with an overall lower ASIR in these communities (Chart 1, middle panel).

Similarly, some variation in stage-specific ASIRs was noted across peer groups. Compared with Peer Group C communities (i.e., a mix of urban and rural communities from coast to coast with a large population of adults aged 65 and older), Stage I ASIRs were significantly lower in Peer Group D and H communities (Table 3), despite the fact that Peer Group D communities are largely rural while Peer Group H communities are primarily urban centres. Two peer groups had significantly higher Stage I and Stage II ASIRs compared with the reference group: Peer Group A, which is composed of rural and remote regions in the Western provinces and the territories, and Peer Group B, which is primarily composed of urban centres with high employment and large racialized or immigrant populations. Less variability was seen for Stage III ASIRs compared with other stages (Table 3).

Breast cancer mortality from 2010 to 2022

Over the study period, the age-standardized mortality rate (ASMR) attributable to breast cancer was 28.3 females per 100,000 every year (Chart 1, upper panel). Compared with the ASMR in Ontario (27.8 per 100,000), five provinces had

Chart 3
Distribution of stage at diagnosis of invasive breast cancer cases among females (2010 to 2020), nationally (excluding Quebec and Nunavut) and by geographic region



* statistically significantly different from age group 50 to 59 based on the test of significance of proportions (Bonferroni-adjusted, $p < 0.01$)

† reference category

Notes: Stage at diagnosis was classified per the American Joint Committee on Cancer (AJCC) Cancer Staging Manual 7th edition from 2010 to 2017 and the AJCC Cancer Staging Manual 8th edition (clinical staging) from 2018 to 2020. Incidence data for Nova Scotia are for 2010 to 2019 only, and no staging data were available for Quebec. Furthermore, data were excluded for the following years in a particular province or territory because fewer than 66.6% of incident cases had staging information: Nova Scotia (2019), New Brunswick (2018 to 2019), Saskatchewan (2018), and Nunavut (2010 to 2020).

Source: Canadian Cancer Registry, 2021 diagnosis year.

statistically significantly higher rates: (1) Newfoundland and Labrador (31.5 per 100,000), (2) Nova Scotia (31.6 per 100,000), (3) Quebec (30.1 per 100,000), (4) Manitoba (29.3 per 100,000), and (5) Saskatchewan (30.3 per 100,000). Conversely, three provinces had statistically significantly lower rates compared with Ontario: (1) Prince Edward Island (23.7 per 100,000), (2) Alberta (27.0 per 100,000), and (3) British Columbia (26.1 per 100,000; Chart 1, upper panel).

The lowest ASMR across community sizes was for communities with a population of 1,500,000 or more (26.3 per 100,000); communities of other sizes had statistically similar ASMRs (Chart 1, middle panel). Of note, whereas the ASIR was highest in communities with a population from 500,000 to 1,499,999, the ASMR for these communities was comparable to that of smaller communities (Chart 1, middle panel).

Compared with Peer Group C (28.9 per 100,000), the ASMR was significantly higher in Peer Group E (30.8 per 100,000), i.e., rural Eastern regions with an older population. It was significantly lower in peer groups G (27.1 per 100,000) and H (22.9 per 100,000; Chart 1, bottom panel), which are composed of the largest cities of Montréal, Vancouver and Toronto (Peer Group G) and other urban centres in Ontario and British Columbia (Peer Group H). Notably, peer groups with higher ASIRs do not necessarily have higher ASMRs.

Discussion

The present study found significant variability in invasive breast cancer incidence, including age and stage-specific rates, and mortality among females in Canada. Compared with Ontario, ASIRs were significantly lower in New Brunswick, Manitoba, Saskatchewan, British Columbia, and Nunavut, but significantly higher in Quebec and Alberta. However, interprovincial and territorial incidence patterns do not necessarily carry through to mortality patterns. For example, when compared with Ontario, ASIRs in Manitoba and Saskatchewan were significantly lower, but ASMRs were significantly higher. While age standardization is meant to remove the influence of different regional age structures, discrepancies between ASIRs and ASMRs may be attributable to other individual- or cancer-related characteristics. In this case, Manitoba and Saskatchewan had significantly higher Stage IV ASIRs, with advanced stage being related to increased mortality. While the present study used standalone incidence (i.e., CCR) and mortality (i.e., CVSD) data sources, future work may wish to integrate diagnosis and mortality information to examine how characteristics at the time of diagnosis are related to survival and mortality. The CCR was recently linked to updated mortality information, including the CVSD, through to the end of 2021; such data would be useful for examining

Table 3

Stage-specific¹ age-standardized incidence rate (per 100,000) of invasive breast cancer cases among females (2010 to 2020),² nationally (excluding Quebec and Nunavut)³ and by geographic region

Geography	Stage I			Stage II			Stage III			Stage IV			Unstaged		
	95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval		
	ASIR	from	to	ASIR	from	to	ASIR	from	to	ASIR	from	to	ASIR	from	to
National	62.7	62.3	63.1	39.8	39.5	40.1	13.9	13.7	14.1	7.1	7.0	7.2	13.2	13.0	13.4
Province or territory															
Newfoundland and Labrador	64.9 *	62.1	67.6	37.3 *	35.2	39.5	14.8	13.4	16.1	10.7 *	9.5	11.8	9.4 *	8.3	10.5
Prince Edward Island	67.7 *	62.3	73.1	39.9	35.8	44.1	12.0	9.7	14.3	7.2	5.4	8.9	8.0 *	6.1	9.8
Nova Scotia	59.7	57.5	61.9	38.4	36.6	40.2	12.5 *	11.5	13.6	8.2 *	7.4	9.0	18.2	17.0	19.5
New Brunswick	61.1	58.6	63.6	41.8	39.8	43.9	14.4	13.2	15.7	7.8 *	6.9	8.7	5.9 *	5.2	6.7
Ontario [†]	60.2	59.6	60.7	39.8	39.3	40.2	14.2	14.0	14.5	6.5	6.4	6.7	17.7	17.4	17.9
Manitoba	64.0 *	62.1	65.9	40.0	38.5	41.5	14.2	13.3	15.1	8.6 *	7.9	9.3	8.0 *	7.3	8.7
Saskatchewan	61.2	59.1	63.4	41.7 *	40.0	43.5	13.8	12.8	14.8	9.2 *	8.4	10.1	8.2 *	7.5	9.0
Alberta	74.0 *	72.7	75.2	41.1 *	40.2	42.0	13.8	13.2	14.3	7.7 *	7.3	8.1	3.9 *	3.6	4.2
British Columbia	62.4 *	61.4	63.3	38.6 *	37.9	39.4	13.1 *	12.6	13.5	6.8	6.5	7.1	10.1 *	9.7	10.4
Yukon	60.3	47.9	72.7	40.5	30.5	50.4	16.3	10.3	22.2	8.9	3.6	14.1	18.6	10.6	26.5
Northwest Territories	67.2	53.6	80.8	42.4	31.7	53.2	17.7	10.2	25.2	3.7	1.2	6.3	13.9	5.5	22.2
Community size (population)															
1,500,000 or more	58.7 *	58.0	59.4	38.1 *	37.5	38.6	13.4	13.0	13.7	6.6 *	6.4	6.9	15.0 *	14.6	15.3
500,000 to 1,499,999	67.9 *	67.0	68.9	42.1 *	41.3	42.8	15.2 *	14.8	15.7	7.1	6.8	7.4	8.3 *	8.0	8.6
100,000 to 499,999 [†]	62.6	61.7	63.5	39.9	39.2	40.6	13.7	13.3	14.1	7.3	7.0	7.6	12.3	11.9	12.7
10,000 to 99,999															
(any CMA or CA less than 100,000)	60.9 *	59.7	62.1	38.6 *	37.7	39.6	13.3	12.8	13.9	7.0	6.6	7.4	13.3 *	12.8	13.9
Less than 10,000															
(any non-CMA or non-CA)	60.3 *	59.4	61.3	37.8 *	37.0	38.6	13.1	12.6	13.5	7.3	7.0	7.6	12.1	11.7	12.6
Health region peer group															
A: Rural and remote regions in the Western provinces and the territories	66.5 *	64.3	68.8	40.4 *	38.7	42.2	13.2	12.2	14.2	8.3 *	7.5	9.1	5.8 *	5.1	6.5
B: Urban centres with high employment and large immigrant and racialized populations	66.0 *	65.3	66.8	41.6 *	41.1	42.2	14.7 *	14.3	15.0	7.1	6.8	7.3	9.9 *	9.7	10.2
C: Sparsely populated urban and rural mix from coast to coast with a large population of seniors (i.e., aged 65 and older) [†]	61.5	60.7	62.4	38.4	37.7	39.1	13.3	12.9	13.7	7.1	6.8	7.4	13.2	12.8	13.6
D: Rural regions in Ontario and the Prairies	58.7 *	57.5	59.8	37.6	36.7	38.5	13.2	12.7	13.7	6.8	6.4	7.2	14.5 *	13.9	15.0
E: Rural Eastern regions with a very large population of seniors (i.e., aged 65 and older)	61.2	58.4	63.9	38.1	35.9	40.4	14.6	13.2	16.0	9.5 *	8.4	10.6	12.3	11.1	13.5
F: Northern and remote regions with a large population of children and youth (i.e., younger than 20)	55.5	46.8	64.2	33.9	27.3	40.4	17.0	12.2	21.9	8.3	4.8	11.9	4.4 *	1.7	7.2
G: Toronto and Vancouver	60.4	59.3	61.5	38.2	37.3	39.1	13.9	13.4	14.5	7.2	6.8	7.6	14.4 *	13.9	14.9
H: Urban centres in Ontario and British Columbia with very high dwelling values	56.8 *	55.9	57.8	38.0	37.2	38.8	12.7	12.3	13.2	6.4 *	6.1	6.7	15.0 *	14.4	15.5

* associated rate ratio (not shown) is statistically significantly different from 1.0 ($p < 0.05$)

[†] Reference category for statistical comparisons

1. Stage at diagnosis was classified per the American Joint Committee on Cancer (AJCC) Staging Manual 7th edition from 2010 to 2017 and the AJCC Staging Manual 8th edition (clinical staging) from 2018 to 2020.

2. Incidence data for Nova Scotia are available only for 2010 to 2019.

3. No staging data are available for Quebec. Furthermore, data are excluded for the following years in a particular province or territory because fewer than 66.6% of incident cases have staging information: Nova Scotia (2019), New Brunswick (2018 to 2019), Saskatchewan (2018), and Nunavut (2010 to 2020).

Notes: ASIR = age-standardized incidence rate; CMA = census metropolitan area; CA = census agglomeration.

Source: Canadian Cancer Registry, 2021 diagnosis year.

survival patterns by geographic location while accounting for characteristics at the time of diagnosis.

Breast cancer is usually diagnosed either through screening (i.e., no symptoms of illness) or clinically by a physician (i.e., symptoms of illness present). In Canada, screening programs differ across a variety of factors, including age of eligibility. For example, whereas most provinces provide screening up to age 75, Quebec ended eligibility at age 70 until February 1, 2024, when females aged 70 to 74 became eligible. Additionally, while most programs initiate screening for females starting at age 50, Alberta lowered the age of eligibility to 45 in 2022,²⁸ and other programs allow females to self-refer starting at age 40.¹⁰ Such screening program differences could explain some of the geographic variability in breast cancer incidence, including age- and stage-specific rates, in the current study.

A strength of this study is the consideration of peer groups, which group together health regions with similar sociodemographic and economic characteristics.²⁴ While this study did not include individuals' sociodemographic or economic characteristics, the use of peer groups acknowledges the health-related importance of such factors.²⁹⁻³² In the present study, females in Peer Group E regions (i.e., rural Eastern regions with a higher proportion of seniors) had a similar overall ASIR and mean age at diagnosis as females in Peer Group C communities (i.e., urban and rural communities with sparse populations and a large population of seniors). However, residents of Peer Group E regions had significantly higher incidence at or after age 80 and Stage IV ASIRs, which may be related to their significantly higher ASMRs than females in Peer Group C communities. Conversely, ASIRs and ASMRs were lower for females in peer group G and H communities (i.e., Montréal, Toronto, and Vancouver and other large urban centres in Ontario and British Columbia). Residents of large urban centres may have different levels of access to particular health services, including diagnostic and treatment services, than residents of rural and less populated regions of the country.³³⁻³⁶ The socioeconomic characteristics of individuals living in these regions may also be associated with varying health and care-seeking behaviours.^{37,38} The present study's findings highlight the need for additional observation of both regional- and individual-level socioeconomic factors and their respective associations with cancer incidence and outcomes.

In their recent examination of early-onset breast cancer in the United States, Kehm et al. noted significant geographic variability in incidence trends, which they likened to "the risk gap between individuals in the highest and lowest percentiles of absolute risk, as determined by polygenic risk scores."³⁹ The authors went on to suggest that place-based factors be incorporated into risk prediction algorithms alongside other established risk factors, such as age, ethnicity, and genetics.³⁹ The geographic variability in the present study also supports considering the impact of geography and place-based risk for breast cancer incidence and mortality in Canada. By contrast to cancer screening strategies that emphasize individual-level

characteristics, geographically targeted approaches may be more feasible to implement, given their clear delineation and practical applicability.

The present study includes some limitations. The first, as previously noted, is missing information in both the CCR and CVSD. While the present study used as much information as was available at the time of analysis, the findings only reflect the regions and years examined. Given decreasing trends in breast cancer incidence³ and mortality⁴ over the last decade, the exclusion of data for more recent years may result in increased estimates of these outcomes. Future examinations of cancer and cancer-specific survival could use more recent data, when available. Relatedly, the present study pooled information from multiple years but did not examine time trends in the relationship between geography and breast cancer outcomes. While pooled data provided a large sample, thereby allowing for greater disaggregation of analyses, this approach may have masked variability over time. Additionally, pooled years include the COVID-19 pandemic period. Studies in both the United States^{40,41} and Canada^{42,43} have noted a drop in cancer incidence rates generally, and breast cancer rates specifically, in 2020 compared with what would have been expected, as well as a shift towards later stages at diagnosis and poorer survival. Specifically, work by Decker et al. (2023) found that pandemic impacts were not equal across all geographic regions. While the inclusion of pandemic-era data may reflect more current realities, pandemic-related changes to cancer diagnoses and outcomes may obscure other patterns of geographic variability. Also, over the study period, Quebec transitioned from an exclusively hospital discharge-based registry to a more integrated central registry. In particular, Quebec cancer cases reported during the transition years (i.e., from 2011 to 2012) may not be comparable to those before or after this period.⁴⁴ Last, the present study assigned geographic classifications to individuals' postal codes based on a single year. While regions and their classification may change over time, such cases are likely at the margins of a category (e.g., a population that is just below 500,000 one year and over that threshold the next year). The impact of this issue may be minimized in the present study because multiple classifications are used (e.g., community size and peer group).

This study highlights important geographic variability in female breast cancer incidence and mortality in Canada. While such differences may simply be because of the characteristics of residents of these regions, the current findings indicate that where a person lives may have an important impact on their cancer-related risk. These findings may provide an argument for examining geographic regions in this country that require additional consideration to minimize or eliminate health disparities.

Appendix Table A

Age-standardized¹ incidence rates of invasive breast cancer among females (2010 to 2020)² and female breast cancer mortality rates (2010 to 2022),³ rates per 100,000 females and rate ratios, nationally and by geographic region

Geography	Age-standardized incidence rate (ASIR)						Age-standardized mortality rate (ASMR)					
	ASIR	95% confidence interval		Rate ratio [†]	95% confidence interval		ASMR	95% confidence interval		Rate ratio [†]	95% confidence interval	
		from	to		from	to		from	to		from	to
National	140.1	139.6	140.7	...	...	...	28.3	28.1	28.5	...	...	...
Province or territory												
Newfoundland and Labrador	137.0	133.0	141.1	0.99	0.96	1.02	31.5 *	29.7	33.3	1.13	1.07	1.20
Prince Edward Island	134.8	127.2	142.4	0.97	0.92	1.03	23.7 *	20.8	26.6	0.85	0.75	0.96
Nova Scotia	137.0	133.9	140.2	0.99	0.97	1.01	31.6 *	30.3	32.9	1.14	1.09	1.19
New Brunswick	128.9 *	125.6	132.1	0.93	0.91	0.96	27.6	26.2	29.0	0.99	0.94	1.04
Quebec	156.3 *	155.0	157.7	1.13	1.12	1.14	30.1 *	29.6	30.5	1.08	1.06	1.10
Ontario [‡]	138.4	137.5	139.2	1.00	...	...	27.8	27.5	28.1	1.00	...	...
Manitoba	134.8 *	132.0	137.6	0.97	0.95	1.00	29.3 *	28.1	30.5	1.05	1.01	1.10
Saskatchewan	134.3 *	131.3	137.3	0.97	0.95	0.99	30.3 *	29.1	31.6	1.09	1.04	1.14
Alberta	140.4 *	138.7	142.1	1.01	1.00	1.03	27.0 *	26.3	27.7	0.97	0.94	1.00
British Columbia	130.9 *	129.6	132.3	0.95	0.93	0.96	26.1 *	25.5	26.6	0.94	0.91	0.96
Yukon	144.4	125.0	163.9	1.04	0.91	1.19	37.8	22.4	53.2	1.36	0.91	2.05
Northwest Territories	144.9	124.1	165.7	1.05	0.91	1.21	28.5	19.2	37.9	1.03	0.74	1.42
Nunavut	70.0 *	46.7	93.2	0.51	0.36	0.71	11.5 *	4.3	18.7	0.41	0.22	0.77
Community size (population)												
1,500,000 or more	129.6 *	128.7	130.5	0.96	0.95	0.98	26.3 *	26.0	26.7	0.90	0.88	0.92
500,000 to 1,499,999	142.3 *	141.0	143.6	1.06	1.05	1.07	28.8	28.3	29.3	0.98	0.96	1.01
100,000 to 499,999 [‡]	134.4	133.2	135.6	1.00	...	...	29.2	28.7	29.8	1.00	...	...
10,000 to 99,999 (any CMA or CA less than 100,000)	133.5	131.9	135.0	0.99	0.98	1.01	28.9	28.3	29.6	0.99	0.96	1.02
Less than 10,000 (any non-CMA or non-CA)	130.0 *	128.7	131.2	0.97	0.95	0.98	29.3	28.8	29.8	1.00	0.98	1.03
Health region peer group												
A: Rural and remote regions in the Western provinces and the territories	134.4	131.1	137.6	1.02	1.00	1.05	29.1	27.6	30.5	1.01	0.96	1.06
B: Urban centres with high employment and large immigrant and racialized populations	138.5 *	137.6	139.5	1.06	1.04	1.07	29.3	28.9	29.6	1.01	0.99	1.03
C: Sparsely populated urban and rural mix from coast to coast with a large population of seniors (i.e., aged 65 and older) [‡]	131.3	130.1	132.5	1.00	...	...	28.9	28.4	29.4	1.00	...	...
D: Rural regions in Quebec, Ontario, and the Prairies	133.5 *	132.1	134.9	1.02	1.00	1.03	29.2	28.6	29.8	1.01	0.99	1.04
E: Rural Eastern regions with a very large population of seniors (i.e., aged 65 and older)	133.2	129.7	136.7	1.01	0.99	1.04	30.8 *	29.3	32.2	1.07	1.01	1.12
F: Northern and remote regions with a large population of children and youth (i.e., younger than 20)	106.1 *	95.9	116.4	0.81	0.73	0.89	27.7	22.7	32.8	0.96	0.80	1.15
G: Montréal, Toronto, and Vancouver	129.3 *	127.9	130.7	0.99	0.97	1.00	27.1 *	26.6	27.7	0.94	0.91	0.96
H: Urban centres in Ontario and British Columbia with very high dwelling values	128.9 *	127.4	130.3	0.98	0.97	1.00	22.9 *	22.3	23.4	0.79	0.77	0.82

... not applicable

* statistically significantly different from the reference category ($p < 0.05$) based on the rate ratios and their confidence intervals

[‡] Reference category for statistical comparisons

[†] compared with the reference category

1. Age standardized to the female population as per population estimates on July 1, 2016.

2. Incidence data are available only from 2010 to 2017 for Quebec and from 2010 to 2019 for Nova Scotia.

3. Yukon mortality data are available only from 2010 to 2016.

Notes: CMA = census metropolitan area; CA = census agglomeration.

Sources: Canadian Cancer Registry, 2021 diagnosis year; and Canadian Vital Statistics - Death database, 2010 to 2022.

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