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Provincial Variation in Adherence to Breast Cancer Screening in Canada: Evidence From the Canadian Partnership for Tomorrow's Health

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ABSTRACT

Background: Breast cancer is the most commonly diagnosed cancer among women in Canada. Screening is effective in reducing breast cancer mortality through early cancer detection. However, data on individual social and medical characteristics contributing to variation in adherence to screening is limited.

Methods: Using multivariable logistic regression, we analyzed self-reported questions on engagement in screening mammography from five regions of the Canadian Partnership for Tomorrow's Health (CanPath), including the BC Generations Project (BCGP), Alberta's Tomorrow Project (ATP), the Ontario Health Study (OHS), Quebec's CARTaGENE, and the Atlantic Partnership for Tomorrow's Health Study (Atlantic PATH).

Results: The study population included 79,986 and 46,907 individuals aged 50–74 and 40–49 years at study enrollment, respectively. Most participants self-reported undergoing screening mammography less than 2 years from study enrollment, ranging from 77.8% in OHS to 86.3% in BCGP. Factors significantly associated with a lower odd of ever undergoing screening mammography were lower household income, being single/never married, current daily smoking, poor self-perceived health, no history of breast feeding, and \geq 24 months since last routine medical check-up by a doctor or nurse. Among women aged 40–49 years with a first-degree family history of breast cancer (N=4212 [8.9%]), the likelihood of ever being screened varied by region and was significantly lower among individuals with post menopause and more than 12 months since last medical check-up.

Conclusion: Factors associated with screening adherence that were identified in this study namely household income, selfperceived health, and routine medical check-ups should be considered as potential factors for targeting undeserved communities and increasing engagement in screening at both provincial and national levels. The observed variation in mammography among women aged 40 to 49 years with family history of breast cancer, may inform the current guidelines for potential benefits of early screening initiation.

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1 | Introduction

Breast cancer is the most commonly diagnosed cancer and the second leading cause of cancer-related death among women in Canada [1, 2]. Breast cancer screening, as a secondary prevention strategy, has been shown to be effective in reducing cancer mortality through early cancer detection [3]. Evidence from observational studies show a 25% to 31% reduction in risk of breast cancer mortality among women aged 50 to 69 years [4].

Established guidelines by the Canadian Task Force on Preventive Health Care (CTFPHC) recommend biennial mammography for average risk women aged 50–74 years [5, 6]. In Canada, organized screening uses a systematic approach for the identification and invitation of the screening eligible population, recall after a normal or benign screening, and regular monitoring and evaluation. Important components of the organized approach to screening in Canada include providing consistent and highquality services, monitoring of screening program elements, integration of screening within the cancer care spectrum, as well as high enrollment and participation [7].

Although individuals at high risk (e.g., family history of breast cancer and genetic mutations) have a greater lifetime risk of developing breast cancer, currently there are no national guidelines, and screening protocols vary across jurisdictions [8]. For instance, although about 10% of breast cancer-related deaths occurs among women aged 40–49 years, the risk of false positive and over diagnosis among this population has resulted in either excluding these individuals from routine screening policies or restricting the mammography only to those with family history of breast cancer in most Canadian jurisdictions [1, 9]. Nevertheless, although the risk of breast cancer is two times higher among women with affected first-degree relative, engagement in mammographic screening among this population remains suboptimal [10, 11].

In Canada, preventive healthcare services, including screening programs, are part of publicly funded healthcare [12]. However, the most recent Canadian Community Health Survey indicates about 78% of Canadian women aged 50-74 years reported a history of breast cancer screening with mammography over the last 3 years [11]. However, an assessment of variation in screening uptake within and between provinces is needed [12]. In a recently conducted study, the inter- and intraprovincial variation in screen-detected breast cancer cases varied from 42% to 52% among women aged 50–69 years [12]. While the observed within provincial variation was largely related to age-group screening eligibility, the between province variation was associated with differences in rural/urban residence and income [12]. However, this study did not assess the potential impact of individual factors, known to be associated with breast cancer and healthseeking behavior [11], such as education, ethnicity, history of pregnancy, and breast feeding as well as use of hormone replacement therapy and contraceptives.

In the current study, we used data from CanPath (the Canadian Partnership for Tomorrow's Health) [13] to identify factors associated with engagement in screening mammography and to estimate the potential variation in screening uptake across regional CanPath cohorts among eligible women (i.e., aged 50–74 years).

We further assessed the potential factors associated with ever being screened among women aged 40 to 49 years with family history of breast cancer.

2 | Methods

2.1 | Study Population

CanPath participants were recruited from 2008 to 2016 from five regional cohorts namely the BC Generations Project (BCGP), Alberta's Tomorrow Project (ATP), the Ontario Health Study (OHS), Quebec's CARTaGENE, and the Atlantic Partnership for Tomorrow's Health Study (Atlantic PATH). Using a Health and Lifestyle Questionnaire (HLQ), data on following social and medical determinants of health at study enrollment were collected: age, sex, education, country of birth, race, marital status, income, self-perceived health, family history of cancer and chronic diseases, physical activity, smoking status, number of pregnancies, breast feeding history, and cancer screening history. For the current analysis, the study population was restricted to women aged 40-74 years with no prior diagnosis of breast cancer. Individuals with missing information on age, cancer status, and/or type and unknown history of breast cancer screening were excluded.

2.2 | Screening Status and Risk Factors

To examine engagement in screening mammography, the HLQ included two questions on lifetime history of breast cancer screening, as well as the timing of the last mammogram at study enrollment (i.e., less than 6 months ago, 6 months to less than 1 year ago, 1 year to less than 2 years ago, 2 years to less than 3 years ago, 3 years to less than 5 years ago, and 5 or more years ago). In this study, we categorized breast cancer screening status as "never screened" if participants reported no previous history of mammography and "ever screened" if participants reported any history of breast cancer screening at study enrollment. We further categorized ever screening status as history of screening "less than two years" if participants reported history of mammography less than 2 years ago, and "more than two years" if participants reported history of mammography more than 2 years ago. In order to examine the impact of family history of breast cancer, adherence to screening mammography was assessed separately among participants with a first-degree family history of breast cancer [8] (i.e., first-degree family history) and screening eligible women aged 50-74 without family history of breast cancer (i.e., average risk). As a sensitivity analysis, we also assessed ever versus never screening status among women aged 40 to 49 years with and without family history of breast cancer.

2.3 | Statistical Analysis

Sociodemographic characteristics of participants stratified by study cohort at enrollment are presented as counts and percentages.

Multivariable logistic regression models were used to assess adherence to the screening mammography among two groups of

ever versus never screened individuals as well as participants with history of breast cancer screening "less than two years" versus "more than two years" ago.

In the models, only variables selected through backward selection were included to evaluate the association between breast cancer screening and potential predictors. Associations were estimated as odds ratios (ORs) with 95% confidence intervals (95% CI).

Variables included in the models were sex, age (i.e., 40-49, 50-59, 60-69, and 70-74 years), total annual household income (i.e., <\$50,000, \$50,000-99,999, ≥\$100,000), education (i.e., no education or less than high school, trade, technical school or diploma from a community college, university certificate below bachelor's level, bachelor's degree, and graduate degree), marital status (i.e., married or living with a partner, divorced, widowed, separated, single/never married), ethnic background (i.e., white, other), first language (i.e., English, French, other), perception of health (i.e., poor, fair, good, very good, and excellent), country of birth (i.e., Canada, other), smoking status (i.e., never smoked at least 100 cigarettes, past smoker (ever smoked at least 100 cigarettes), current occasional smoker, current daily smoker), and level of physical activity (i.e., low, moderate, or high). Models were also adjusted for the presence of comorbidities (defined as any occurrence of at least one of the following conditions: asthma, arthritis or rheumatism, high blood pressure, migraine headaches, chronic bronchitis or emphysema, sinusitis, diabetes, epilepsy, heart disease, cancer, stomach or intestinal ulcers, effects of a stroke, urinary incontinence, bowel disorders, Alzheimer's disease or dementia, cataracts, glaucoma, and thyroid dysfunction), time since last routine medical check-up by a doctor or a nurse (<12 months, ≤ 12 to <24 months, \geq 24 months), number of pregnancies (0, 1, 2, \geq 3), total lifetime duration of breast feeding $(0, \le 12 \text{ months}, > 12 \text{ months})$, ever use of hormone replacement therapy (HRT) (no/yes), ever use of hormone fertility treatment (HFT) (no/yes), ever use of contraceptives (no/yes), and menopause (no/yes). Due to the selfreported nature of the data, missing values in this study were categorized as "unknown" and were included in the analysis.

All analyses were performed using SAS version 9.4 (Cary, NC, USA). Ethical approval was provided by the Health Research Ethics Board, University of British Columbia.

3 | Results

3.1 | Sociodemographic Characteristics at Study Enrollment

From a total of 261,760 respondents at enrollment in CanPath, 79,986 average risk individuals aged 50–74 years, including 11,155 (14.0%) from BCGP, 13,374 (16.7%) from ATP, 36,871 (46.1%) from OHS, 11,898 (14.9%) from CARTaGENE, and 6688 (8.4%) from Atlantic PATH, met the inclusion criteria (Table 1 and Figure 1). Additionally, 17,416 individuals aged 40–74 years with a family history of breast cancer, including 2355 (13.5%) from BCGP, 3324 (19.1%) from ATP, 7986 (45.9%) from OHS, 1974 (11.3%) from CARTaGENE, and 1777 (10.2%) from Atlantic PATH, were included in the study (Table 2 and Figure 1).

Tables 1 and 2 summarize the sociodemographic characteristics of individuals with average risk and first-degree family history of breast cancer, respectively. Overall, across all CanPath regions, in both groups most participants were married or living with a partner (family history: 69.8%), were white (family history: 78.2%), and were among never smokers (family history: 48.9%). Furthermore, greater proportions of participants had household incomes \$50,000-99,999 (family history: 34.5%), with an education level of trade, technical school, or diploma from community college (family history: 34.5%), had very good self-perceived health (family history: 41.6%), had a high level of physical activity (family history: 33.00%), with no comorbid conditions (family history: 39.5%), and with less than 12 months since last routine medical check-up by a doctor or nurse (family history: 68.6%). Furthermore, in both first-degree family history and average risk groups, history of at least three pregnancies (family history: 43.3%), \leq 12 months lifetime duration of breast feeding (family history: 33.5%), ever use of contraceptives (88.3%), and menopause (family history: 68.1%) were reported more frequently compared to other categories. Among both average risk and family history groups across all provinces, about 95% of individuals reported history of lifetime breast cancer screening. In total, 80.0% of average risk group and 84.1% of family history group were among regular screening category.

Table 3 presents predictors of adherence to breast cancer screening among ever versus never screened individuals in average risk participants and individuals with family history group. Overall, compared to OHS (the CanPath region with the largest number of participants), the likelihood of being ever screened compared to being never screened was higher across all regions, ranging from 21% in CARTaGENE to 51% in ATP among average risk individuals (Table 3). Similar patterns were observed among individuals with family history of breast cancer. In both groups, lower household income, marital status other than married or living with a partner, current daily smoking status, no history of breast feeding or more than 12 months of lifetime breast feeding, and more than 12 months since last routine medical check-up by a doctor or nurse, were significant barriers of ever being screened. Additionally, among average risk individuals, poor, fair, and good self-perceived health status compared to excellent category were significant barriers of ever being screened with mammography (OR poor: 1.80; 1.44-2.26). In contracts, older age (average risk groups), presence of comorbidity, ever use of contraceptives in both groups, and ever use of HFT and HRT, were significantly associated with higher odds of ever being screened.

Table 4 displays the predictors of adherence to breast cancer screening among individuals with history of screening less than 2 years compared to more than 2 years ago. Among both groups, the likelihood of being screened less than 2 years ago was significantly higher in ATP compared with OHS. Overall, house-hold incomes < 50,000, marital status other than being married or living with a partner, being a current or past smoker, low level of physical activity, poor self-perceived health, and \geq 24 months since last routine medical check-up by a doctor or nurse were significantly associated with lower adherence to screening within the last 2 years. Among average risk individuals, ever use of HRT and HFT, and menopause were significantly associated with being screened less than 2 years ago.

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	0HS N (%)
Total	79,986	6688	13,374	11,155	11,898	36,871
	100.0	8.4	16.7	14.0	14.9	46.1
Lifetime breast cancer screening						
Never	3780	299	342	294	659	2186
	4.73	4.47	2.56	2.64	5.54	5.93
Ever	76,206	6389	13,032	10,861	11,239	34,685
	95.27	95.53	97.44	97.36	94.46	94.07
Breast cancer screening status						
Never	3780	299	342	294	659	2186
	4.73	4.47	2.56	2.64	5.54	5.93
Less than 2 years	63,994	5303	11,076	9621	9307	28,687
	80.00	79.29	82.82	86.25	78.22	77.81
More than 2 years	12,212	1086	1956	1240	1932	5998
	15.27	16.23	14.62	11.11	16.24	16.26
Age						
50-59	47,435	4153	7732	5557	7519	22,474
	59.30	62.09	57.81	49.82	63.20	60.95
60–69	30,170	2466	5128	5584	4339	12,653
	37.72	36.87	38.34	50.00	36.47	34.32
70–74	2381	69	514	14	40	1744
	2.98	1.03	3.84	0.12	0.33	4.73
Household income						
<\$50,000	20,394	1838	2945	2878	3783	8950
	25.50	27.48	22.02	25.80	31.79	24.27
\$50,000-\$99,999	27,490	2582	4405	4233	3990	12,280
	34.37	38.60	32.94	37.94	33.53	33.30
≥\$100,000	22,527	1687	4961	3229	2596	10,054
	28.16	25.22	37.09	28.95	21.82	27.27
Unknown	9575	581	1063	815	1529	5587
	11.97	8.69	7.95	7.31	12.85	15.53
						(Continues)

TABLE 1 Summary characteristics of Canadian Partnership for Tomorrow's Health (CanPath) by region.

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TABLE I (Continued)	Outomo 11 N/ (97)	Atlantic DATH N (%)	ATD M (%)		CAPT-CENE N (%)	(20) IN SHU
-	(a) at marca o					
Education						
No education, or less than high school	20,346 75 44	1546 22-11	3633 27.16	2467 211	3060	9640 2615
	44. C2	11.62	01.12	11.22	71.77	C1.02
Trade, technical school or diploma from community	27,020	2628	4850	3703	3894	11,945
college	33.78	39.29	36.26	33.20	37.73	32.40
University certificate below bachelor's	4506	385	735	761	993	1632
	5.63	5.76	5.50	6.82	8.35	4.43
Bachelor's degree	17,718	1351	2853	2542	2483	8489
	22.15	20.20	21.33	22.79	20.87	23.02
Graduate degree	9604	754	1298	1625	1210	4717
	12.01	11.27	9.70	14.57	10.17	12.79
Unknown	792	24	S	57	258	448
	0.99	0.36	0.04	0.51	2.17	1.21
First language learned						
English	57,025	5725	11,819	9688	814	28,979
1	71.30	85.60	88.37	86.85	6.84	78.60
French	14,501	876	523	316	10,047	2739
	18.13	13.10	3.91	2.83	84.44	7.43
Other	8460	87	1032	1151	1037	5153
	10.57	1.30	7.72	10.32	8.71	13.97
Marital status						
Married or living with a partner	53,925	5078	9673	7848	7316	24,010
	67.42	75.93	72.33	70.35	61.49	65.12
Divorced	11,584	660	1834	1529	1998	5563
	14.48	9.87	13.71	13.70	16.79	15.09
Widowed	4902	406	878	614	564	2440
	6.13	6.07	6.56	5.50	4.74	6.62
Separated	3020	194	295	324	419	1788
	3.78	2.90	2.21	2.90	3.52	4.85
						(Continues)

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	0HS N (%)
Single, never married	5807	326	691	796	1358	2636
	7.26	4.87	5.17	7.14	11.41	7.15
Unknown	748	24	3	44	243	434
	0.03	0.36	0.02	0.39	2.04	1.17
Self-perceived health						
Poor	1396	65	85	106	233	206
	1.74	0.97	0.63	0.95	1.96	2.46
Fair	6791	496	694	670	1266	3665
	8.49	7.42	5.19	6.00	10.64	9.94
Good	25,336	2019	3931	3085	5177	11,124
	31.68	30.19	29.39	27.66	43.51	30.17
Very good	32,593	3000	6246	4841	3780	14,726
	40.75	44.86	46.70	43.40	31.77	39.94
Excellent	13,432	1100	2417	2393	1130	6392
	16.79	16.45	18.07	21.45	9.50	17.34
Unknown	438	8	1	60	312	57
	0.55	0.12	0.01	0.54	2.62	0.15
Country of birth						
Canada	64,810	6294	11,526	8410	10,648	27,932
	81.03	94.11	86.18	75.39	89.49	75.76
Other	15,176	394	1848	2745	1250	8939
	18.97	5.89	13.82	24.61	10.51	24.24
Ethnicity						
White	62,062	5617	8313	9542	8823	29,767
	77.59	83.98	62.16	85.54	74.15	80.73
Other	17,924	1071	5061	1613	3075	7104
	22.41	16.02	37.84	14.46	25.85	19.27
Physical activity level						
Low	17,782	1999	1914	1408	2557	9904
	22.23	29.89	14.31	12.62	21.49	26.86
						(Continues)

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTAGENE N (%)	OHS N (%)
Moderate	22,461	2034	3136	2568	3743	10,980
	28.08	30.41	23.45	23.02	31.46	29.78
High	24,912	2337	3954	3586	3735	11,300
	31.14	34.94	29.56	32.15	31.39	30.65
Unknown	14,831	318	4370	3593	1863	4687
	18.54	4.75	32.68	32.21	15.66	12.71
Smoking status						
Never smoked at least 100 cig	37,887	3114	6779	5713	4696	17,585
	47.37	46.56	50.69	51.21	39.47	47.69
Past smoker (ever at least 100 cigarettes)	30,929	2835	4523	4767	5032	13,772
	38.67	42.39	33.82	42.73	42.29	37.35
Current occasional smoker	1542	130	149	141	407	715
	1.93	1.94	1.11	1.26	3.42	1.94
Current daily smoker	6905	522	811	414	1491	3667
	8.63	7.80	6.06	3.71	12.53	9.95
Unknown	2723	87	1112	120	272	1132
	3.40	1.30	8.31	1.08	2.29	3.07
Presence of comorbidity						
0	28,207	2533	5110	3808	4172	12,584
	35.26	37.87	38.21	34.14	35.06	34.13
1	23,653	2268	4693	3137	2173	11,382
	29.57	33.91	35.09	28.12	18.26	30.87
7	13,657	1294	2490	1674	1561	6638
	17.07	19.35	18.62	15.00	13.12	18.00
S	4695	443	800	541	424	2487
	5.87	6.62	5.98	4.85	3.56	6.74
4	2132	115	222	298	551	946
	2.67	1.72	1.66	2.67	4.63	2.57
S	7587	26	55	1669	3017	2820
	9.48	0.39	0.41	14.96	25.36	7.65

TABLE 1 | (Continued)

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	(%) N SHO
Unknown	55 0.07	9 013	4 0.03	28 0.25	0	14 0.04
Time Since last routine medical check-up by a doctor or a nurse						-
<12 months	54,953	4727	9361	6984	8836	25,045
	68.70	70.68	69.99	62.61	74.26	67.93
\leq 12 to < 24 months	15,751	1065	2584	2539	1731	7832
	19.69	15.92	19.32	22.76	14.55	21.24
≥24 months	7859	729	983	1422	974	3751
	9.83	10.90	7.35	12.75	8.19	10.17
Unknown	1423	167	446	210	357	243
	1.78	2.50	3.33	1.88	3.00	0.66
Pregnancy						
0	11,004	800	1531	1751	1649	5273
	13.76	11.96	11.45	15.70	13.86	14.30
1	9110	745	1194	1329	1679	4163
	11.39	11.14	8.93	11.91	14.11	11.29
2	24,186	2234	4031	3287	3574	11,060
	30.24	33.40	30.14	29.47	30.04	30.00
≥3	34,877	2881	6590	4717	4838	15,851
	43.60	43.08	49.27	42.29	40.66	42.99
Unknown	809	28	28	71	158	524
	1.01	0.42	0.42	0.63	1.33	1.42
Total lifetime duration of breast feeding						
0	18,660 23.33	2169 32.43	2832 21.17	1659 14.87	5203 43.73	6797 18.43
≤12 months	27,533	2309	5071	3905	3377	12,871
	34.42	34.52	37.92	35.01	28.38	34.91
> 12 months	15,993	1118	3841	3220	1164	6650
	19.99	16.72	28.72	28.86	9.78	18.04
Unknown	17,800	1092	1630	2371	2154	10,553
	22.25	16.33	12.19	21.25	18.10	28.62
						(Continues)

 TABLE 1
 (Continued)

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	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	(%) N SHO
Ever use of hormone replacement therapy						
No	49,622	3912	7820	6130	7624	24,136
	62.04	58.49	58.47	54.95	64.07	65.46
Yes	29,172	2211	5539	4915	4016	12,491
	36.47	33.06	41.42	44.06	33.75	33.88
Unknown	1192	565	15	110	258	244
	1.49	8.45	0.11	0.99	2.17	0.66
Ever use of hormone fertility treatment						
Νο	73,394	6383	12,707	10,552	11,109	32,643
	91.76	95.44	95.01	94.59	93.37	40.81
Yes	4155	249	647	531	633	2095
	5.19	3.72	4.84	4.76	5.32	5.68
Unknown	2437	56	20	72	156	2133
	3.05	0.84	0.15	0.65	1.31	5.79
Ever use of contraceptives						
No	10,282	699	1501	1098	1916	5068
	12.85	10.45	11.22	9.84	16.10	13.74
Yes	69,213	5965	11,866	10,005	9824	31,553
	86.53	89.19	88.72	89.69	82.57	85.58
Unknown	491	24	7	52	158	250
	0.62	0.36	0.05	0.47	1.33	0.68
Menopause						
Νο	12,820 16.03	1149 17.18	2058 15.39	1549 13.89	2207 18.55	5857 15.88
Yes	65,939	5439	11,155	9422	9365	30,558
	82.44	81.32	83.41	84.46	78.72	82.88
Unknown	1227	100	161	184	326	456
	1.53	1.49	1.20	1.65	2.74	1.24



FIGURE 1 | Study flow diagram.

As a sensitivity analysis, the association between participant characteristics and screening patterns among individuals aged 40 to 49 was assessed. In total, 46,907 individuals, including 4212 (8.98%) with a family history of breast cancer and 42,695 (91.0%) with no family history of breast cancer were in their 40s at study enrollment (Table 5). Overall, across all provinces, 87% of individuals aged 40-49 years with a family history of breast cancer had engaged in breast cancer screening. In general, among individuals aged 40-49 years with family history of breast cancer, the likelihood of ever being screened in their 40s was significantly lower among participants who were post menopause (OR 1.83, 95% CI 1.34-2.50), and those who had gone more than 12 months since last routine medical check-up by a doctor or nurse (OR 3.32, 95% CI 1.97-5.60). Among individuals in their 40s with no family history of breast cancer, household incomes < \$50,000, divorced marital status, low level

of physical activity, no history of breast feeding or more than 12 months of lifetime breast feeding, post menopause, and more than 12 months since last routine medical check-up by a doctor or nurse were significantly associated with lower odds of ever being screened (results not shown).

4 | Discussion

In this study, adherence to breast cancer screening guidelines across eight provinces in Canada was assessed using data from five regional cohorts in CanPath. Overall, among average risk populations, the majority of participants were in the "ever screened" category. Similarly, a higher proportion of individuals with a family history of breast cancer were among ever screeners, ranging from 94% in OHS to 97% in BCGP. Among individuals

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	(%) N SHO
Total	17,416	1777	3324	2355	1974	7986
Lifetime breast cancer screening						
Never	764	66	85	57	66	457
	4.39	3.71	2.56	2.42	5.02	5.72
Ever	16,652	1711	3239	2298	1875	7529
	95.61	96.29	97.44	97.58	94.98	94.28
Breast cancer screening status						
Never	764	66	85	57	66	457
	4.39	3.71	2.56	2.42	5.02	5.72
Less than 2 years	14,649	1533	2914	2123	1606	6473
	84.11	86.27	87.67	90.15	81.36	81.05
More than 2 years	2003	178	325	175	269	1056
	11.50	10.02	9.78	7.43	13.63	13.22
Age						
40-49	4212	435	713	425	450	2189
	24.18	24.48	21.45	18.05	22.80	27.41
50-59	7147	740	1444	897	808	3258
	41.04	41.64	43.44	38.09	40.93	40.80
60–69	5578	588	1035	1032	602	2214
	32.03	33.09	31.14	43.82	35.92	27.72
70–74	479	14	132	1	7	325
	2.75	0.79	3.97	0.04	0.35	4.07
Household income						
<\$50,000	4086	434	626	549	690	1787
	23.46	24.42	18.83	23.31	9.37	12.26
\$20,000-\$99,999	6009	669	1046	914	663	2717
	34.50	37.65	31.47	38.81	34.95	22.38
≥\$100,000	5576	510	1390	737	436	2503
	32.02	28.70	41.82	31.30	33.59	34.02
Unknown	1745	164	262	155	185	679
	10.02	9.23	7.88	6.58	22.09	31.34
						(Continues)

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TABLE 2 (Continued)	(A) II (A)	Atlantic DATH NI (0)	VD N (0)		CADTOCENIE N1(0)	
	OVERALLIN (70)		WILIN (%)	DUGE IN (%)	CARIAGENEN (%)	
Education						
No education, or less than high school	4146	371	861	541	547	1826
	23.81	20.88	25.90	22.97	0.56	22.87
Trade, technical school or diploma from community	6007	687	1246	789	638	2647
college	34.49	38.66	37.49	33.50	27.71	33.15
University certificate below bachelor's	931	104	178	137	187	325
	5.35	5.85	5.36	5.82	32.32	4.07
Bachelor's degree	4010	388	713	546	389	1974
	23.02	21.83	21.45	23.18	9.47	24.72
Graduate degree	2198	222	325	321	202	1128
	12.62	12.49	9.78	13.63	19.71	14.12
Unknown	124	Ŋ	1	21	11	86
	0.71	0.28	0.03	0.89	10.23	1.08
First language learned						
English	13,254	1540	2967	2091	118	6538
	76.10	86.66	89.26	88.79	5.98	81.87
French	2889	220	156	74	1750	689
	16.59	12.38	4.69	3.14	88.65	8.63
Other	1273	17	201	190	106	759
	7.31	0.96	6.05	8.07	5.37	9.50
Marital status						
Married or living with a partner	12,160	1358	2520	1680	1234	5368
	69.82	76.42	75.81	71.34	62.51	67.22
Divorced	2242	151	384	303	317	1087
	12.87	8.50	11.55	12.87	16.06	13.61
Widowed	882	85	168	115	92	422
	5.06	4.78	5.05	4.88	4.66	5.28
Separated	655	60	65	56	74	400
	3.76	3.38	1.96	2.38	3.75	5.01

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	(%) N SHO
Single, never married	1395	119	187	188	253	648
	8.01	6.70	5.63	7.98	12.82	8.11
Unknown	82 0.47	4 0.23	00.00	13 0.55	4 0.20	61 0.76
Self-perceived health						
Poor	276	13	18	22	30	193
	1.58	0.73	0.54	0.38	1.52	2.42
Fair	1423	130	158	130	243	762
	8.17	7.32	4.75	0.93	12.31	9.54
Good	5371	556	942	654	870	2349
	30.84	31.29	28.34	5.52	44.07	29.41
Very good	7245	787	1587	1074	632	3165
	41.60	44.29	47.74	27.77	32.02	39.63
Excellent	3063	288	618	466	179	1512
	17.59	16.21	18.59	45.61	9.07	18.93
Unknown	38 0.22	3 0.17	$1 \\ 0.030$	9 19.79	20 1.01	5 0.06
Country of birth						
Canada	14,728	1681	2908	1862	1799	6478
	84.57	94.60	87.49	79.07	91.13	81.12
Other	2688	96	416	493	175	1508
	15.43	5.40	12.52	20.93	8.87	18.88
Ethnicity						
White	13,616 78.18	1495 84.13	2178 65.52	$1998 \\ 84.84$	1294 65.55	6651 83.28
Other	3800	282	1146	357	680	1335
	21.82	15.87	34.48	15.16	34.45	16.72
Physical activity level						
Low	3915	531	471	364	375	2174
	22.48	29.88	14.17	15.46	19.00	27.22
						(Continues)

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	(%) N SHO
Moderate	5189	549	861	688	630	2461
	29.79	30.89	25.90	29.21	31.91	30.82
High	5747	619	1053	902	631	2542
	33.00	34.83	31.68	38.30	31.97	31.83
Unknown	2565	78	939	401	338	809
	14.73	4.39	28.25	17.03	17.12	10.13
Smoking status						
Never smoked at least 100 cigarettes	8513	863	1709	1210	809	3922
	48.88	48.57	51.41	51.38	40.98	49.11
Past smoker (ever at least 100 cigarettes)	6609	727	1088	996	826	2972
	37.95	40.91	32.73	42.29	41.84	37.22
Current occasional smoker	353	35	36	32	78	172
	2.03	1.97	1.08	1.36	3.95	2.15
Current daily smoker	1476	130	193	89	249	815
	8.48	7.32	5.81	3.78	12.61	10.21
Unknown	465	22	298	28	12	105
	2.67	1.24	8.97	1.19	0.61	1.31
Presence of comorbidity						
0	6885	725	1390	966	787	3017
	39.53	40.80	41.82	41.02	39.87	37.78
1	5361	616	1123	747	451	2424
	30.78	34.67	33.78	31.72	22.85	30.35
7	2771	284	570	347	293	1277
	15.91	15.98	17.15	14.73	14.84	15.99
c	972	118	180	109	67	498
	5.58	6.64	5.42	4.63	3.39	6.24
4	403	23	50	38	70	222
	2.31	1.29	1.50	1.61	3.55	2.78
S	1012	8	10	145	306	543
	5.81	0.45	0.30	6.16	15.50	6.80
						(Continues)

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	(%) N SHO
Unknown	12	З	1	ŝ	0	5
	0.07	0.17	0.03	0.13	0.00	0.06
Time since last routine medical check-up by a doctor or a nurse						
<12 months	11,955	1278	2380	1444	1406	5447
	68.64	71.92	71.60	61.32	71.23	68.21
\leq 12 to < 24 months	3447	274	614	562	310	1687
	19.79	15.42	18.47	23.86	15.70	21.12
\geq 24 months	1703	187	223	308	177	808
	9.78	10.52	6.71	13.08	8.97	10.12
Unknown	311	38	107	41	81	44
	1.79	2.14	3.22	1.74	4.10	0.55
Pregnancy						
0	2535	245	382	381	279	1248
	14.56	13.79	11.49	16.18	14.13	15.63
1	1970	201	303	269	286	911
	11.31	11.31	9.12	11.42	14.49	11.41
2	5248	585	666	710	620	2334
	30.13	32.92	30.05	30.15	31.41	29.23
≥3	7545	738	1635	984	785	3403
	43.32	41.53	49.19	41.78	39.77	42.61
Unknown	118	8	5	11	4	06
	0.68	0.45	0.15	0.47	0.20	1.13
Total lifetime duration of breast feeding						
0	3615	503	639	358	768	1347
	20.76	28.31	19.22	15.20	38.91	16.87
≤12 months	5834	591	1250	766	614	2613
	33.50	33.26	37.61	32.53	31.10	32.72
> 12 months	3995	352	1030	751	209	1653
	22.94	19.81	30.99	31.89	10.59	20.70
Unknown	3972	331	405	480	383	2373
	22.81	18.63	12.18	20.38	19.40	29.71
						(Continues)

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	(%) N SHO
Ever use of hormone replacement therapy						
No	12,118	1085	2274	1501	1413	5845
	69.58	61.06	68.41	63.74	71.58	73.19
Yes	4960	433	1043	829	548	2107
	28.48	24.37	31.38	35.20	27.76	26.38
Unknown	338	259	7	25	13	34
	1.94	14.58	0.21	1.06	0.66	0.43
Ever use of hormone fertility treatment						
No	15,998	1694	3146	2222	1870	7066
	91.86	95.33	94.65	94.35	94.73	88.48
Yes	999	66	172	114	102	545
	5.74	3.71	5.17	4.84	5.17	6.82
Unknown	419	17	6	19	2	375
	2.41	0.96	0.18	0.81	0.10	4.70
Ever use of contraceptives						
No	1990	176	351	211	293	959
	11.43	9.90	10.56	8.96	14.84	12.01
Yes	15,375	1595	2971	2137	1677	6995
	88.28	89.76	89.38	90.74	84.95	87.59
Unknown	51	6	2	7	4	32
	0.29	0.34	0.06	0.30	0.20	0.40
Menopause						
No	5348	571	938	587	599	2653
	30.71	32.13	28.22	24.93	30.34	33.22
Yes	11,860	1183	2356	1729	1347	5245
	68.10	66.57	70.88	73.42	68.24	65.68
Unknown	208	23	30	39	28	88
	1.19	1.29	0.90	1.66	1.42	1.10

Study population	Average risk $N = 79,986$ Family history $N = 13,$	
Variable	Odds ratio (95% CI)Tuniny instory it = 10Odds ratio (95% CI)Odds ratio (95% CI)	
Region		
BCGP	0.74 (0.65–0.85)	0.68 (0.40-1.14)
Atlantic PATH	0.48 (0.43-0.54)	0.55 (0.36-0.86)
ATP	0.49 (0.43-0.55)	0.61 (0.39–0.95)
CARTaGENE	0.79 (0.67–0.84)	0.88 (0.50–1.55)
OHS	1.00	1.00
Age		
50-59	1.00	NA
60–69	0.51 (0.46-0.56)	NA
70-74	0.54 (0.41-0.71)	NA
Household income		
<\$50,000	1.68 (1.51–1.86)	NA
\$50,000-\$99,999	1.20 (1.08–1.31)	NA
\geq \$100,000	1.00	NA
Unknown	1.25 (1.10–1.42)	NA
First language learned		
English	NA	1.00
French	NA	0.93 (0.55–1.55)
Other	NA	1.75 (1.14–2.68)
Marital status		
Married or living with a partner	1.00	1.00
Divorced	1.15 (1.04–1.27)	1.45 (1.01–2.08)
Widowed	0.96 (0.82–1.14)	0.83 (0.43–1.60)
Separated	1.25 (1.08–1.46)	1.69 (0.96–2.99)
Single, never married	1.25 (0.99–1.28)	1.15 (0.97–2.38)
Unknown	1.24 (0.91–1.70)	3.51 (1.17–10.53)
Smoking status		
Never smoked at least 100 cigarettes	1.00	1.00
Past smoker (ever smoked at least 100 cigarettes)	0.98 (0.90–1.06)	1.46 (1.08–1.99)
Current occasional smoker	1.39 (1.12–1.72)	1.85 (0.78–4.38)
Current daily smoker	1.69 (1.53–1.88)	2.59 (1.76-3.83)
Unknown	1.02 (0.82–1.26)	0.66 (0.20-2.17)
Self-perceived health		
Poor	1.80 (1.44–2.26)	NA
Fair	1.31 (1.30–1.51)	NA
Good	1.17 (1.04–1.30)	NA

TABLE 3 | Predictors of breast cancer screening comparing ever (reference category) versus never screening status among average risk population and individuals with family history of breast cancer aged 50–79 years.

TABLE 3 | (Continued)

Study population	Average risk N=79,986		
Variable	Odds ratio (95% CI)	Odds ratio (95% CI)	
Very good	1.03 (0.93–1.15) NA		
Excellent	1.00 NA		
Unknown	1.29 (0.83–2.01)	NA	
Presence of comorbidity			
0	1.00	1.00	
1	0.78 (0.71-0.85)	0.71 (0.51-0.97)	
2	0.76 (0.68–0.85)	0.51 (0.32-0.81)	
3	0.74 (0.62–0.87)	0.44 (0.20-0.95)	
4	0.72 (0.57-0.91)	0.89 (0.38-2.08)	
5	0.69 (0.60-0.80)	0.77 (0.44–1.35)	
Total lifetime duration of breast feeding			
0	1.33 (1.21–1.47)	NA	
$\leq 12 \text{ months}$	1.00	NA	
>12 months	1.27 (1.15–1.40)	NA	
Unknown	1.29 (1.17–1.43) NA		
Ever use of contraceptives			
No	1.00	1.00	
Yes	0.66 (0.60-0.73)	0.76 (0.53–1.09)	
Unknown	0.94 (0.65–1.36)	4.40 (1.38–14.00)	
Ever use of hormone fertility treatment			
No	1.00	NA	
Yes	0.77 (0.65–0.92) NA		
Unknown	0.87 (0.69–1.08)	NA	
Ever use of hormone replacement therapy			
No	1.00	NA	
Yes	0.40 (0.36-0.44)	NA	
Unknown	0.77 (0.59–1.00)	NA	
Menopause			
No	1.00	1.00	
Yes	0.48 (0.45-0.53)	0.61 (0.44–0.84)	
Unknown	0.81 (0.64–1.02)	1.32 (0.54–3.24)	
Time since last routine medical check-up by a doctor or a nurse			
<12 months	1.00	1.00	
\leq 12 to < 24 months	1.34 (1.22–1.47)	1.72 (1.19–2.47)	
\geq 24 months	4.26 (3.91-4.63)	5.70 (4.13-7.86)	
Unknown	4.86 (4.13-5.72)	8.04 (4.69-13.79)	

Note: Not applicable (NA): variables not selected through backward selection.

TABLE 4 Predictors of breast cancer screening comparing less than 2 years (reference category) to more than 2 years.

Study population	Average risk N=79,986Family history N=13,204		
Variable	Odds Ratio (95% CI)		
Region			
BCGP	1.04 (0.96–1.12)	0.81 (0.66–1.01)	
Atlantic PATH	0.95 (0.89–1.01)	0.94 (0.79–1.11)	
ATP	0.60 (0.56-0.65)	0.58 (0.47-0.70)	
CARTaGENE	0.98 (0.92–1.05)	1.01 (0.84–1.22)	
OHS	1.00	1.00	
Age			
50-59	1.00	1.00	
60–69	0.96 (0.91–1.00)	0.98 (0.86–1.11)	
70–74	1.30 (1.15–1.46)	1.77 (1.34–2.34)	
Race/cultural origin			
White	1.00	NA	
Other	1.07 (1.01–1.13)	NA	
Household income			
<\$50,000	1.24 (1.17–1.32)	1.20 (0.97–1.50)	
\$50,000-\$99,999	1.08 (1.02–1.14)	1.28 (1.07–1.54)	
≥\$100,000	1.00	1.00	
Unknown	1.10 (1.02–1.19)	1.20 (0.97–1.50)	
Country of birth			
Canada	1.00	NA	
Other	1.14 (1.08–1.20)	NA	
Marital status			
Married or living with a partner	1.00	1.00	
Divorced	1.23 (1.16–1.31)	1.28 (1.07–1.51)	
Widowed	1.23 (1.13–1.33)	1.14 (0.90–1.44)	
Separated	1.31 (1.18–1.45)	1.46 (1.08–1.96)	
Single, never married	1.13 (1.03–1.23)	1.25 (1.00–1.60)	
Unknown	1.41 (1.14–1.74)	2.63 (1.27–5.42)	
Smoking status			
Never smoked at least 100 cigarettes	1.00	1.00	
Past smoker (ever smoked at least 100 cigarettes)	1.08 (1.04–1.13)	0.97 (0.85–1.11)	
Current occasional smoker	1.10 (0.95–1.28)	1.42 (0.94–2.15)	
Current daily smoker	1.53 (1.42–1.64)	1.61 (1.32–1.96)	
Unknown	1.20 (1.07–1.35)	0.96 (0.66–1.40)	
Physical activity level			
Low	1.06 (1.0–1.12)	NA	
Moderate	0.95 (0.90–1.00)	NA	

 TABLE 4
 (Continued)

Study population	Average risk N=79,986	Family history N=13,204	
Variable	Odds Ratio (95% CI)		
High	1.00	NA	
Unknown	0.92 (0.86–0.98) NA		
Self-perceived health			
Poor	1.77 (1.53–2.06)	1.81 (1.22–2.68)	
Fair	1.50 (1.37–1.64)	1.27 (1.00–1.60)	
Good	1.18 (1.11–1.27)	0.95 (0.80-1.14)	
Very good	1.04 (0.97–1.10)	0.77 (0.64–0.91)	
Excellent	1.00	1.00	
Unknown	1.31 (0.97–1.77)	0.61 (0.17–2.21)	
Presence of comorbidity			
0	1.00	NA	
1	0.94 (0.90-0.99)	NA	
2	0.98 (0.92–1.04)	NA	
3	1.04 (0.95–1.14)	NA	
4	1.10 (0.97–1.24)	NA	
5	1.09 (1.00–1.18)	NA	
Pregnancy			
0	0.81 (0.73–0.89)	NA	
1	0.89 (0.83-0.96)	NA	
2	0.89 (0.84–0.93)	NA	
≥3	1.00	NA	
Unknown	1.01 (0.82–1.26)	NA	
Total lifetime duration of breast feeding			
0	1.04 (0.98–1.10)	NA	
$\leq 12 \text{ months}$	1.00	NA	
>12 months	1.09 (1.03–1.16)	NA	
Unknown	1.17 (1.08–1.27)	NA	
Ever use of contraceptives			
No	1.00		
Yes	0.93 (0.87–0.98)	NA	
Unknown	0.70 (0.52–0.94)	NA	
Ever use of hormone fertility treatment			
No	1.00	NA	
Yes	0.85 (0.77-0.93)	NA	
Unknown	0.86 (0.75-1.00)	NA	

Study population	Average risk N=79,986 Family history N=13,2				
Variable	Odds Ratio (95% CI)				
Ever use of hormone replacement therapy					
No	1.00	NA			
Yes	0.80 (0.77–0.84)	NA			
Unknown	0.93 (0.78–1.10)	NA			
Menopause					
No	1.00	NA			
Yes	0.92 (0.87–0.98)	NA			
Unknown	0.97 (0.81–1.16)	NA			
Time since last routine medical check-up by a doctor or a nurse					
<12 months	1.00	1.00			
\leq 12 to $<$ 24 months	1.71 (1.62–1.79)	1.66 (1.43–1.93)			
\geq 24 months	5.92 (5.59-6.27)	6.73 (5.78–7.85)			
Unknown	4.03 (3.56-4.57)	5.14 (3.70-7.15)			

Note: Screening status among average risk population and individuals with family history of breast cancer, aged 50–79 years. Not applicable (NA): variables not selected through backward selection.

TABLE 5 | Breast cancer screening status among: (A) all women aged 40–49 years and (B) women aged 40–49 years with family history of breast cancer, by region.

	Overall N (%)	Atlantic PATH N (%)	ATP N (%)	BCGP N (%)	CARTaGENE N (%)	OHS N (%)	
A. Breast cancer screening status among all participants							
Never	17,567	1436	1361	754	3946	10,070	
	37.45	34.52	20.85	18.81	46.38	42.49	
Less than	20,858	2141	4182	2882	2668	8985	
2 years	44.47	51.47	64.05	71.91	31.36	37.91	
More than	8482	583	986	372	1894	4647	
2 years	18.08	14.01	15.10	9.28	22.26	19.61	
Total	46,907	4160	6529	4008	8508	23,702	
	100.00	8.87	13.92	8.54	18.14	50.53	
B. Breast cancer screening status among individuals with family history of breast cancer							
Never	531	49	57	31	66	328	
	12.61	11.26	7.99	7.29	14.67	14.98	
Ever	3681	386	656	394	384	1861	
	87.39	88.74	92.01	92.71	85.33	85.02	
Total	4212	435	713	425	450	2189	
	100.00	10.33	16.93	10.09	10.68	51.97	

aged 40–49 years with a first-degree family history of breast cancer, the majority of participants had a history of ever being screened, ranging from 85% in CARTaGENE to 92% in BCGP. In multivariable regression analysis among average risk and participants with family history of breast cancer, the likelihood of being screened less than 2 years ago was significantly higher in ATP compared to OHS (the CanPath region with the largest number of participants). Overall, lower household income, current daily smoking, no history of breast feeding and more than 12 months since last routine medical check-up by a doctor or nurse were among factors identified as significant barriers to screening uptake.

According to the Canadian Partnership Against Cancer (CPAC), adherence of 70% or higher to mammography screening is recommended as an effective strategy for reducing breast

cancer-related mortality in the general population [14]. Our findings show that the participation rate in all CanPath regions exceeded this target. In a recently conducted study in Alberta, adherence to screening at enrollment was 79%, which was in line with the 83% estimated rate in our study (1515). Nevertheless, in a population-based cohort study conducted in Ontario in 2011, 64% of women aged 50–74 had history of at least one mammogram over the last 24 months, which was lower than the estimated 78% among average risk women in Ontario (OHS) in the current study [15]. Overall, the observed variation between regional cohorts in this study was minimal.

Similar to previously conducted studies, the present study found that several modifiable and non-modifiable factors were significantly associated with regular or never screening. It has been shown that having a family doctor was significantly associated with regular screening [15–17]. Our study supports this finding as we observed a significant association between having a routine check-up performed more than 12months ago and never screening. Our results on the association of household income and regular screening echo the findings reported by two studies conducted in Ontario and Alberta [15, 18]. We further observed that racial origin other than white was significantly associated with episodic screening. However, due to limited diversity in race within CanPath participants, we were not able to further disaggregate "other" racial origin. In a study conducted by Woods et al. in British Columbia, significant variation in screening participation across country of birth was observed and Eastern European/Central Asian women showed low participation rate (38%) [19]. Overall, in the Woods study, participation rates for immigrant women from the most common birth countries, including China/Macau/Hong Kong/Taiwan (46%), India (45%), the Philippines (46%), and South Korea (39%), were lower than the nonimmigrant rates (51%) [19]. Hence, strategies for improving mammography adherence in women of racial and ethnic minorities may be required. These strategies could include reminders as well as educational interventions, taking into account the potential language barriers among minorities and immigrants [20].

Our finding on the potential associations between age and mammography partly supports the reported nonlinear association of increased screening adherence by age, followed by a decline among older participants [15, 21]. In the current study, compared with never being screened, the likelihood of regular screening was higher among individuals aged 60–69 years, in both average risk and first-degree family history groups (Tables 3 and 4). Lower participation among the younger age in this analysis might be related to their lower self-perceived risk of breast cancer which could potentially lead to underdiagnosis of cancer among this population and requires further investigation [12].

In Canada, some provinces and territories (i.e., British Columbia, Alberta, Nova Scotia, Prince Edward Island, and Northwest Territories) include women aged 40–49 years in their organized breast cancer screening program [1]. The potential risk of false positive and overdiagnosis of nonprogressive tumors might outweigh the benefits of screening among women in their 40s [1, 4, 9]. However, in a study conducted by Wilkinson et al., using Canadian Community Health Survey (CCHS) data between 2002 and 2007, the 10-year breast cancer net survival rate

was significantly higher in provinces including women aged 40–49 years in their screening program [1, 22]. In our study, we observed significant variation in adherence to screening among individuals aged 40–49 years with first-degree family history of breast cancer, ranging from 85% in CARTaGENE to 92% in BCGP. Considering the reported benefits of screening namely cancer diagnosis at earlier stage and reduced cancer-related death, future studies are required to further assess the risk-benefit of regular screening among women aged 40–49 years [23–25].

In a meta-analysis conducted by Katapodi et al., the association between perceived risk of breast cancer and adherence to screening was influenced by a patient's physiological and psychological factors [26]. In a study conducted by Yuan et al., history of hypertension and hyperlipidemia were associated with increased mammography screening, while prior heart attack was associated with decreased annual mammographic screening [21]. In our study, the presence of comorbid conditions, especially having up to three conditions was associated with higher likelihood of adherence to screening, which could be related to more frequent medical check-ups [27]. Future studies should explore to what extent adherence to regular screening could be influenced by the presence of comorbid conditions and estimate the "underutilization" of screening programs among healthy women [10, 26].

Evidence shows that current or recent use of progestogen-only contraceptives are associated with a slight increase in breast cancer risk [28, 29]. Additionally, it is well known that prolonged estrogen exposure and combined HRT or estrogen-only HRT usage for menopause are associated with increased risk of breast cancer [29, 30]. These findings highlight the importance of regular medical check-ups as well as routine screening in this population. Similarly, in our study individuals with ever use of contraceptives, HRT, with menopause at study enrollment, or with higher risk of breast cancer, were more likely to regularly screen. However, HRT makes mammography screening less effective by adversely affecting the sensitivity and specificity of the test [30, 31]. Hence, factors including type of prescribed HRT and short-term cessation of HRT therapy before mammography should be further explored in studies assessing the patterns of screening behavior among women on these therapies [32].

To our knowledge, this is the first Pan-Canadian study to assess factors associated with breast cancer screening uptake in a general population cohort. The harmonized questionnaires in CanPath support the internal validity of the study and comparability of datasets across the different Canadian regions [13]. CanPath's large study sample, drawn from across eight provinces, enabled us to include participant-level information, namely education, race/ethnicity, perceived health, cigarette smoking, presence of comorbidity conditions, and ever use of HFT and HRT. Hence, in this study, we were able not only to assess adherence to breast cancer screening recommendations but also to highlight the potential factors associated with adherence to regular screening, which can support future policy decision-making. Despite these strengths, the following limitations should be considered while interpreting the results. First, the self-reported nature of responses could potentially bias the derived estimates and associations, yet the observed variation is unlikely to be

differential across study regions [33, 34]. Second, the generalizability of the findings could be affected by the voluntary enrollment of the participants in CanPath [35]. Furthermore, since data on follow-up screening were not available, we were not able to assess the screening retention rates among participants, especially among individuals with first-degree family history of breast cancer, in different regions. Finally, due to lack of information on genetic mutations, adherence to screening program among individuals at higher risk of breast cancer was solely assessed among participants with family history of breast cancer.

In conclusion, the majority of participants in the five regions of CanPath engaged in mammographic screening in alignment with current breast cancer screening recommendations, with slight variations among specific groups between regions. The potential factors associated with screening adherence that were identified, specifically household income, self-perceived health, and routine medical check-ups, should be considered as potential factors for targeting undeserved communities and improving engagement in screening at both provincial and national levels. The observed variation in mammography among women aged 40–49 years with family history of breast cancer may inform the current guidelines for potential benefits of early screening initiation.

Author Contributions

M. Darvishian: conceptualization (equal), formal analysis (equal), methodology (equal), writing – original draft (equal). A. Moustaqim-Barrette: conceptualization (equal), methodology (equal), writing – review and editing (equal). P. Awadalla: conceptualization (equal), writing – review and editing (equal). P. Bhatti: investigation (equal), methodology (equal), writing – review and editing (equal). P. Broet: conceptualization (equal), writing – review and editing (equal). R. A. Murphy: conceptualization (equal), methodology (equal), writing – review and editing (equal). K. Skead: conceptualization (equal), writing – review and editing (equal). R. Urquhart: conceptualization (equal), writing – review and editing (equal). J. Vena: conceptualization (equal), writing – review and editing (equal). T. J. B. Dummer: conceptualization (equal), methodology (equal), supervision (equal), writing – review and editing (equal).

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Ethics Statement

Ethical approval was provided by the Health Research Ethics Board, University of British Columbia. All participants in the CanPath provided written informed consent for participation in the study.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data analyzed in this study is subject to the following licenses/restrictions: "The data that support the findings of this study are available on request from CanPath—The Canadian Partnership for Tomorrow's Health (formerly CPTP). The data are not publicly available due to privacy or ethical restrictions." Data access requests should be submitted to CanPath, https://canpath.ca/access-process/.

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