

## Health Reports

# Updated breast cancer costs for women by disease stage and phase of care using population-based databases

by Nicole Mittmann, Soo Jin Seung, Zharmaine Ante, Ning Liu, Jean HE Yong, Abeer Yusuf, Anna M Chiarelli, and Craig C Earle

Release date: November 20, 2024



Statistics  
Canada

Statistique  
Canada

Canada

---

## How to obtain more information

For information about this product or the wide range of services and data available from Statistics Canada, visit our website, [www.statcan.gc.ca](http://www.statcan.gc.ca).

You can also contact us by

**Email at** [infostats@statcan.gc.ca](mailto:infostats@statcan.gc.ca)

**Telephone**, from Monday to Friday, 8:30 a.m. to 4:30 p.m., at the following numbers:

- Statistical Information Service 1-800-263-1136
- National telecommunications device for the hearing impaired 1-800-363-7629
- Fax line 1-514-283-9350

## Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner. To this end, Statistics Canada has developed standards of service that its employees observe. To obtain a copy of these service standards, please contact Statistics Canada toll-free at 1-800-263-1136. The service standards are also published on [www.statcan.gc.ca](http://www.statcan.gc.ca) under “Contact us” > “[Standards of service to the public](#).”

## Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Published by authority of the Minister responsible for Statistics Canada

© His Majesty the King in Right of Canada, as represented by the Minister of Industry, 2024

Use of this publication is governed by the Statistics Canada [Open Licence Agreement](#).

**An [HTML version](#) is also available.**

*Cette publication est aussi disponible en français.*

---

# Updated breast cancer costs for women by disease stage and phase of care using population-based databases

by Nicole Mittmann, Soo Jin Seung, Zharmaine Ante, Ning Liu, Jean HE Yong, Abeer Yusuf, Anna M Chiarelli, and Craig C Earle

**DOI:** <https://www.doi.org/10.25318/82-003-x202401100001-eng>

## ABSTRACT

### Background

This study assessed health care system costs and resource utilization for adult women with breast cancer in Ontario, Canada. The goal was to update costs by stage, age, and phase of care from a health care system perspective.

### Data and methods

A retrospective analysis was conducted using linked population-based administrative data. The study included women diagnosed with breast cancer from 2017 to 2021, with follow-up data until 2022. Cases were matched with controls in a 1:5 ratio using birth year, local health integrative network, income quintile, and resource utilization band at baseline. Incremental costs were estimated using linear regression. The modified income quintile was the neighbourhood- or area-level income quintile.

### Results

Among the 37,133 cases matched with 185,665 controls, the average age at diagnosis was 62 years. For the entire study duration, cases incurred an additional cost of \$27,485 per year, compared with controls. Costs rose with disease severity, ranging from \$15,588 for stage I to \$137,319 for stage IV. The highest incremental costs occurred during the first 12 months after diagnosis (initial: \$43,408), followed by the last 12 months before death (terminal: \$25,940), and then interim years (continuous: \$9,533 per year). Additionally, the incremental cost of breast cancer was higher when diagnosis was before age 70 (\$28,415), compared with diagnosis at age 70 and older (\$25,254).

### Interpretation

The findings align with previous studies on breast cancer costs for the health care system. Additionally, variations in costs based on disease severity, care phase, and age were emphasized, highlighting higher costs for metastatic breast cancer cases, women younger than 70 years, and the initial 12 months following diagnosis.

### Keywords

breast cancer, health care costs, resource utilization, disease stage, phases of care, Canada

## AUTHORS

Nicole Mittmann is with Clinical Evaluative Sciences at Sunnybrook Research Institute and is employed by Canada's Drug Agency (CDA-AMC). Soo Jin Seung and Abeer Yusuf are with the Health Outcomes and PharmacoEconomics (HOPE) Research Centre at Sunnybrook Research Institute. Zharmaine Ante, Ning Liu and Craig C Earle are with ICES (Institute for Clinical Evaluative Sciences) Central. Craig C Earle and Jean HE Yong are with the Canadian Partnership Against Cancer. Anna M Chiarelli is with Ontario Health.

**B**reast cancer represents 26% of new cancer cases in women, with around 30,000 diagnoses in Canada in 2023.<sup>1</sup> Managing breast cancer involves a range of health care settings and has considerable implications on health care resources. While studies have looked at breast cancer costs in Canada by subtype<sup>2</sup> and stage,<sup>3</sup> there is a gap in understanding breast cancer costs related to phase of care and disease stage. A number of studies have reported breast cancer costs outside Canada recently,<sup>4-6</sup> but health care costs often vary by health system. Linked population-level health care administrative data provide estimates of health care costs and resource utilization patterns for breast cancer. Understanding these costs and factors is critical for informing health care policy decisions.

This study aimed to estimate the incremental health care costs (annualized) associated with a breast cancer diagnosis for women by disease stage, age, and phase of care in Ontario, Canada, from a public health care payer perspective, based on resources from population-level data.

## Methods

### Data sources and study design

This study used health care administrative data located at ICES. The ICES Data Repository encompasses much of the publicly funded administrative health services records for the Ontario population (about 15 million people). Various linked data from databases were used in this study to capture information about cancer diagnosis and health care resources used. These databases include the Ontario Cancer Registry (OCR), physician and non-physician claims submitted to the Ontario Health Insurance Plan (OHIP), medical and chemotherapy drug claims submitted to the Ontario Drug Benefit and New Drug Funding Program (NDFP), discharge summaries of hospital stays and emergency department visits, and claims for home care and long-term care (see Appendix 1). Further descriptions of these databases can be found in previous literature.<sup>7</sup>

Cases included in this study were women aged 18 years or older with a valid OHIP card who were diagnosed with breast cancer in the OCR using the International Classification of Diseases for Oncology, third edition, codes C500 to C509 from April 1, 2017, to March 31, 2021. Women were excluded if they had a prior breast cancer diagnosis or a history of any other cancer at any time prior to the breast cancer diagnosis. Women who were long-term care home residents in the year prior to diagnosis were excluded. Controls came from a population of women in the Registered Persons Database never diagnosed with breast cancer (or previous cancer) and who were still alive at the time of the case's diagnosis (the index date for both cases and matched controls). Additionally, women who had never been diagnosed with other cancers prior to the index date and had not been admitted to a long-term care facility were also able to be control cases. Cases were matched to controls in a 1:5 ratio, given the gain of statistical power and the large base population of women with no breast cancer diagnosis.<sup>8</sup>

Cases were matched to five population controls by birth year, local health integration network, modified income quintile, and resource utilization band at index date. Modified income quintile was the neighbourhood- or area-level income quintile, derived from Statistics Canada's Postal Code Conversion File v2016, adjusted for rurality of residence to account for potential misclassifications of income quintiles in rural areas. The Johns Hopkins Adjusted Clinical Groups System methodology<sup>9</sup> was used with six resource utilization bands, representing health care resource use over a period of two years prior to the index date.

### Statistical and costing analysis

The study outlined baseline characteristics using mean, median, and proportions, comparing these factors between cases and controls via standardized differences. Mean costs per woman and per year were determined using the GETCOST methodology and described elsewhere.<sup>10</sup> The mean cost per woman per year was based on the follow-up period, standardized by 365 days, and the mean was calculated for the group. The costing period was from the index date of cancer diagnosis (from April 1, 2017, to March 31, 2021) and followed all cases and controls up to death, end of OHIP eligibility, new cancer diagnosis, or September 30, 2022—whichever was earliest. Costs were based on resource utilization components such as inpatient hospitalizations; emergency department visits; outpatient clinic visits, including cancer clinic visits; physician visits, including those with medical oncologists and family physicians; chemotherapies and other drug prescriptions; home care visits; and diagnostic procedures. Some of these resource utilization components could be considered cost drivers more than others.

The mean cost per woman was calculated by dividing the cohort's total cost by the number of women who were alive and eligible at the start of the costing period, including those who did not use health care services. The mean cost per woman per year was calculated by dividing the cohort's total cost by the total person-years. Costs were categorized by age group and cancer stage at diagnosis. The age groups were 18 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, and 80 and older for demographics; for costs, the age groups were younger than 70, and 70 and older. The cancer stages at diagnosis were stages I, II, III, and IV, as well as ductal carcinoma in situ and unknown or missing. Costs were further analyzed in three phases of care: initial (first 365 days after diagnosis), continuing (interim years), and terminal (last 365 days of life for individuals who were deceased, from any cause). For those with less than 24 months of follow-up, their time was allocated first to the terminal phase (if deceased), then to the initial phase, and finally to the continuing phase. Patient mortality was included in the costing of the terminal phase, and no other weighted approach was used to estimate the impact of attrition on costs.

Breast cancer attributable or incremental costs were calculated by determining incremental mean costs (with 95% confidence intervals) using linear regression models with generalized estimating equations accounting for matched clusters. These

models used an individual’s accrued cost as the dependent variable and their case or control status as the predictor. When individuals with at least one day of follow-up in a particular phase were considered, the incremental costs based on that phase of care were calculated, potentially leading to instances where a deceased case might not have all five matched controls in the terminal phase, and vice versa. Statistical analyses were conducted at ICES using SAS Enterprise Guide 8.3. For baseline characteristics, standard differences were used instead of p-values to examine the magnitude of imbalance between the cases and the controls. A standard difference of less than 0.10 indicated no meaningful differences in the characteristics of the groups that were being compared.

## Results

### Baseline characteristics

Within the study time horizon, 42,848 women were diagnosed with breast cancer, and 37,133 cases of breast cancer were matched with 185,665 controls (Figure 1). Table 1 summarizes the characteristics of matched case and control cohorts. The average age of all women was 61.8 years ± 13.3 years. More women lived in urban areas, with a relatively even distribution among income quintiles.

### Costs

Table 2 shows overall mean costs per woman per year by stage and age group of women, based on follow-up period and standardized by 365 days, for both case and control cohorts. Among all women and all stages, cases had an overall mean cost of \$33,831, with \$6,346 for controls and with a \$27,485

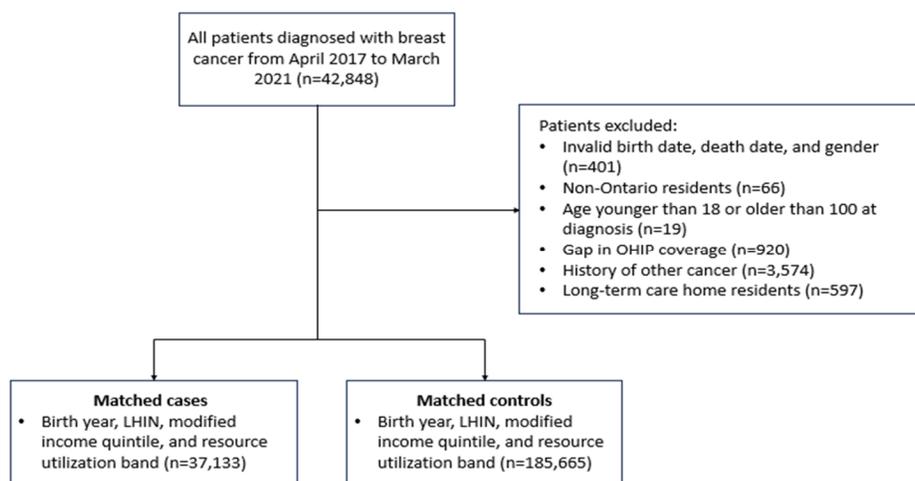
incremental cost attributable to breast cancer. The incremental costs for women by stage showed that all women with stage I breast cancer had overall costs of \$15,588, stage II had overall costs of \$27,649, stage III had overall costs of \$43,266, and stage IV had overall costs of \$137,319. Women with stage IV breast cancer had the highest incremental costs, which aligned with higher systemic therapy drug costs (via the NDFP) during advanced disease stages. Women aged younger than 70 years at all stages had lower mean costs (\$32,464 for the case group and \$4,050 for the control group) that led to the highest incremental cost (\$28,415). Women aged 70 years and older at all stages had higher mean costs (\$37,119 for cases and \$11,865 for controls), and the incremental cost was \$25,254.

A second costing approach was used, based on the three phases of care—initial, continuous, and terminal (see Table 3). Incremental costs between cases and controls were highest during the initial phase (\$43,408), followed by the terminal phase (\$25,940), and then the continuing phase (\$9,533). Major cost drivers for cases only in the initial and continuing phases included outpatient cancer clinic visits, physician visits, and chemotherapy drug costs. In the terminal phase, the major cost driver was inpatient hospitalizations.

## Discussion

The objective of this study was to determine and update overall and incremental costs, stratified by age, phase of care, and disease stage, for women diagnosed with breast cancer using matched population controls. These results will be used to populate the OncoSim microsimulation models, which are web-based simulation tools that evaluate cancer control strategies via the Canadian Partnership Against Cancer. Using these results in

**Figure 1**  
Study patient diagram



**Note:** OHIP: Ontario Health Insurance Plan; LHIN: local health intergration networks

**Source:** Ontario Cancer Registry and Registered Persons Database.

**Table 1**  
**Baseline characteristics for number of matched breast cancer case and control groups**

Characteristic	Total	Cases	Controls	Standard difference
<b>Total</b>	222,798	37,133	185,665	...
<b>Age at index date (years)</b>				
Mean	61.8	61.8	61.8	0.000
Median	62	62	62	0.000
<b>Age group</b>				
18 to 39	10,477	1,742	8,735	0.001
40 to 49	31,252	5,166	26,086	0.004
50 to 59	54,360	9,111	45,249	0.004
60 to 69	61,252	10,210	51,042	0.000
70 to 79	43,402	7,231	36,171	0.000
80 and older	22,055	3,673	18,382	0.000
<b>Rurality</b>				
Urban	198,680	33,114	165,566	0.000
Rural	23,972	3,995	19,977	0.000
<b>Modified income quintile</b>				
1 (lowest)	35,550	5,925	29,625	0.000
2	38,832	6,472	32,360	0.000
3	39,528	6,588	32,940	0.000
4	40,260	6,710	33,550	0.000
5 (highest)	44,490	7,415	37,075	0.000
6 (rural areas)	23,940	3,990	19,950	0.000
<b>Resource utilization band</b>				
0 (none)	2,664	444	2,220	0.000
1 (healthy user)	1,686	281	1,405	0.000
2 (low)	16,044	2,674	13,370	0.000
3 (moderate)	124,980	20,830	104,150	0.000
4 (high)	51,126	8,521	42,605	0.000
5 (highest)	26,298	4,383	21,915	0.000

... not applicable

**Sources:** Ontario Cancer Registry, Postal Code Conversion File, and Registered Persons Database.

OncoSim microsimulation models may help researchers and policy advisors in the cancer prevention, screening, and treatment domains to forecast the impact of policy changes on cancer-related outcomes such as economic burden, incidence, and mortality.<sup>11</sup>

Three recent costing studies in individuals with a diagnosis of breast cancer have been conducted. Harfouche and colleagues examined costs using a cohort of women with breast cancer identified from a Portuguese hospital.<sup>4</sup> The costs (in 2014 euros) associated with diagnosis and treatment of 807 newly diagnosed women and men, within a two-year time horizon, were calculated. Cost by stage was determined using fixed and variable cost models. Results presented were aggregate costs (€6.6 million) by stage and not per individual. The cost driver was related to clinic care, which included clinic costs, chemotherapy, and immunomodulating drugs (49.8%). The study had a small population and followed individuals for a two-year period. By contrast, results presented in the present study were based on a recent population cohort, over a five-year period, and had a control group. The cost drivers in the present study had some similarities and included outpatient cancer clinic visits, physician visits, and chemotherapy drug costs for

the initial and continuous phase and inpatient hospitalizations for the terminal phase.

Another notable costing study was conducted by Kreis and colleagues, who examined costs for women with a diagnosis of breast cancer using data from an administrative database from 2011 to 2014.<sup>5</sup> A state administrative database was used to identify resources related to inpatient, outpatient, medication, medical aid, rehabilitation, sick leave, and travel expenses. The breast cancer incremental cost (in 2011 euros) was determined in a 1:2 ratio matched control group adjusted by gender, age and comorbidities. Time was divided into initial, intermediate, and terminal phases of care. The study used a population cohort and disaggregated costs and had a control group. By contrast, the results presented in the present study were based on newer administrative database information.

The findings of the present study are aligned with those of other costing studies. It should be noted that the original cost values are included in this discussion, followed in parentheses by the inflated or converted cost values in 2022 Canadian dollars to assist with comparisons. A Canadian study reported attributable breast cancer costs in 2008 Canadian dollars (two-year mean costs per case), and found the breast cancer attributable cost to

be \$31,732 (\$42,064), with costs of \$29,938 (\$39,686) for stage I, \$46,893 (\$62,162) for stage II, \$65,369 (\$86,654) for stage III, and \$66,627 (\$88,322) for stage IV.<sup>3</sup> A literature review of articles using claims data from Germany<sup>6</sup> in 2021 euros—including the study by Kreis and colleagues—reported the same higher stage, higher incremental breast cancer cost trend as found in the present study: €21,523 (\$32,201) for stage I, €25,679 (\$38,419) for stage II, €30,156 (\$45,117) for stage III, and €42,086 (\$62,966) for stage IV.<sup>5,6</sup> The 2014 Portuguese study by Harfouche and colleagues used activity-based costing and found that stage I to IV one-year costs in 2014 euros per patient were lower than those reported in Germany, at €6,095 (\$9,968), €9,785 (\$16,004), €11,893 (\$19,451), and €14,536 (\$23,773), respectively.<sup>4</sup> A 2018 systematic review assessing 15 global breast cancer resource costing studies reported cumulative mean costs in U.S. dollars of \$29,724 (\$47,782) for stage I, \$39,322 (\$63,211) for stage II, \$57,827 (\$92,958) for stage III, and \$62,108 (\$99,840) for stage IV,<sup>12</sup> reflecting the same increase in costs with breast cancer staging as the findings of the present study. Lastly, a recent Canadian study used aggregate costing methods and an expert panel to estimate mean costs per case in 2023 Canadian dollars of \$39,263 for stage I, \$76,446 for stage II, \$97,668 for stage III, and \$370,398 for stage IV.<sup>2</sup> All studies reported increasing incremental breast cancer costs with increasing disease stage, as

calculated in the present study. It should be noted that health systems were different in these studies, and costs can vary based on the availability of health care resources.

The present study also determined incremental costs based on phase of care, with initial, continuing, and terminal phases examined. The results showed that incremental costs were higher during the initial and terminal phases. This can be explained by various factors, such as diagnosis, treatment intensity and duration, disease progression, and patient specifics. In the claims data study from Germany,<sup>5,6</sup> results showed an initial phase incremental cost of €21,499 (\$32,165), an intermediate phase cost of €2,620 (\$3,918), and a terminal phase cost of €34,513 (\$51,635) per incident case. The present study’s incremental costs for the initial and continuous phases were aligned well with these findings, although its terminal phase incremental cost was lower than that reported in Germany. The terminal phase periods were defined differently, as 18 to 24 months preceding death in the Kreis and colleagues study, compared with the last 365 days of life for deceased individuals in the present study. The increased terminal phase duration could contribute to the higher terminal phase incremental cost of €34,513 (\$51,635), compared with the terminal phase incremental cost of \$25,940 in the present study.

**Table 2**  
**Mean and incremental costs in dollars per woman per year among breast cancer cases and controls, overall and stratified by age group**

Age group/ Stage	Cases		Controls		Incremental cost per year	95% confidence interval	
	Mean cost per woman per year	Standard deviation	Mean cost per woman per year	Standard deviation		from	to
<b>Total</b>							
All	33,831	73,291	6,346	32,777	27,485	26,724	28,247
DCIS	16,166	72,217	5,602	30,412	10,563	7,710	13,416
I	21,871	39,474	6,282	34,457	15,588	15,000	16,177
II	33,575	37,473	5,925	27,102	27,649	26,714	28,585
III	49,674	58,062	6,408	32,904	43,266	41,055	45,476
IV	144,385	208,515	7,066	29,851	137,319	127,422	147,216
<b>Younger than 70 years</b>							
Total	32,464	67,073	4,050	27,933	28,415	27,587	29,243
DCIS	15,813	77,405	4,440	29,765	11,374	7,937	14,810
I	21,733	25,762	4,258	31,776	17,475	16,984	17,965
II	34,711	38,080	3,495	17,505	31,216	30,153	32,279
III	49,485	50,481	3,850	24,120	45,635	43,412	47,858
IV	142,719	226,964	3,653	20,908	139,066	125,467	152,665
<b>70 years or older</b>							
Total	37,119	86,350	11,865	41,689	25,254	23,592	26,917
DCIS	17,466	48,503	9,858	32,320	7,608	3,344	11,873
I	22,195	60,467	11,029	39,643	11,166	9,574	12,757
II	30,475	35,593	12,529	42,877	17,946	16,080	19,811
III	50,159	74,085	13,060	48,211	37,098	31,671	42,526
IV	147,165	173,558	12,744	39,935	134,421	120,903	147,938

**Note:** DCIS: ductal carcinoma in situ.

**Sources:** Canadian Institute for Health Information Continuing Care Reporting System, Discharge Abstract Database, National Ambulatory Care Reporting System, and National Rehabilitation Reporting System; New Drug Funding Program; Ontario Drug Benefit Formulary; Ontario Health Insurance Plan billings; and Ontario Home Care Database.

**Table 3**  
**Health care resource utilization cost in dollars among breast cancer cases and controls by phase of care**

Cohort / Cost label	Cases		Controls		Incremental cost per year	95% confidence interval		
	Mean cost per woman per year	Standard deviation	Mean cost per woman per year	Standard deviation		from	to	
<b>Initial</b>								
Total costs	46,957	37,976	3,549	10,676	43,408	43,007	43,809	
Inpatient hospitalization costs	2,695	8,647	672	5,392	2,023	1,930	2,115	
Outpatient cancer clinic costs	19,732	20,205	6	358	19,726	19,518	19,935	
Other outpatient costs	4,018	2,922	235	623	3,783	3,753	3,813	
Emergency department costs	317	608	139	433	177	171	184	
Physician visit costs	7,408	3,533	1,037	1,531	6,371	6,333	6,409	
Non-physician visit costs	17	47	16	45	1	0	1	
Systemic therapy drug costs	4,295	13,305	1	253	4,295	4,157	4,432	
Ontario Drug Benefit Formulary drug costs	2,887	6,831	666	2,605	2,221	2,149	2,292	
Laboratory costs	132	142	68	94	64	62	65	
Same-day surgery costs	3,713	2,561	148	674	3,565	3,538	3,591	
Complex and continuing care costs	100	2,890	92	2,616	9	-24	41	
Home care costs	1,380	2,800	256	2,066	1,124	1,094	1,154	
Rehabilitation costs	127	1,946	87	1,566	39	18	61	
<b>Continuing</b>								
Total costs	13,772	25,527	4,239	12,413	9,533	9,258	9,809	
Inpatient hospitalization costs	1,220	6,933	860	6,259	360	282	438	
Outpatient cancer clinic costs	3,996	11,154	7	385	3,989	3,871	4,106	
Other outpatient costs	1,134	1,660	260	734	874	856	892	
Emergency department costs	204	533	172	1,009	32	24	39	
Physician visit costs	2,155	2,362	1,159	1,981	996	969	1,022	
Non-physician visit costs	19	36	17	37	2	1	2	
Systemic therapy drug costs	1,790	9,488	2	365	1,789	1,689	1,889	
Ontario Drug Benefit Formulary drug costs	1,772	7,623	813	3,259	959	877	1,040	
Laboratory costs	80	95	68	93	12	11	13	
Same-day surgery costs	458	1,320	181	970	277	262	292	
Complex and continuing care costs	136	3,401	117	3,041	19	-20	58	
Home care costs	557	3,060	349	2,593	208	175	242	
Rehabilitation costs	90	1,616	70	1,332	20	2	38	
<b>Terminal</b>								
Total costs	66,381	58,627	40,440	59,583	25,940	23,470	28,411	
Inpatient hospitalization costs	21,762	33,030	22,183	45,860	-421	-2,013	1,172	
Outpatient cancer clinic costs	12,627	19,681	40	1,281	12,587	11,912	13,261	
Other outpatient costs	3,835	4,399	911	2,117	2,924	2,765	3,083	
Emergency department costs	1,459	1,317	1,211	1,286	248	193	302	
Physician visit costs	8,537	6,294	4,744	5,771	3,794	3,537	4,050	
Non-physician visit costs	10	28	11	52	-2	-3	0	
Systemic therapy drug costs	2,901	12,118	22	1,282	2,878	2,463	3,294	
Ontario Drug Benefit Formulary drug costs	4,564	11,867	2,146	4,870	2,418	1,995	2,841	
Laboratory costs	100	136	89	126	11	6	17	
Same-day surgery costs	589	1,601	209	1,347	380	317	444	
Complex and continuing care costs	2,963	15,101	2,282	13,089	681	79	1,283	
Home care costs	5,722	9,468	4,435	9,336	1,287	889	1,686	
Rehabilitation costs	693	4,303	819	5,211	-126	-320	67	

**Sources:** Canadian Institute for Health Information, Continuing Care Reporting System, Discharge Abstract Database, National Ambulatory Care Reporting System, and National Rehabilitation Reporting System; New Drug Funding Program; Ontario Drug Benefit Formulary; Ontario Health Insurance Plan billings; and Ontario Home Care Database.

Although the aforementioned costing studies had slightly different time frames and may define phases of care differently, they each helped to analyze the costs of breast cancer treatment by stage and phase of care. It is ideal to catch and treat breast cancer as early as possible, not only for improved patient

prognosis and survival purposes, but also because the incremental costs for women by stage were lowest for stage I breast cancer, with an overall cost of \$15,588. Using the updated overall and incremental costs stratified by age, phase of care, and disease stage for women diagnosed with breast cancer

with matched population controls, the present study had ultimate objective of determining and helping to plan how to best allocate limited health care resources based on where the resources are needed the most.

## Limitations

While the use of real-world data on health care utilization and costing is a major strength of this study, there are some limitations worth noting. First, hormone receptor and HER2 status was not consistently available for all women diagnosed with breast cancer in the administrative databases and could not be used as another type of stratification for incremental breast cancer costs. This may lead to an underestimate of costs. Second, the Ontario Drug Benefit Formulary provides information on outpatient drug prescriptions for people aged 65 and older, or for those on social assistance, so drug costs for those younger than 65 are not available. This likely underestimates actual costs. Third, while the systemic therapy drug costs in the NDFP database include most of the new breast cancer treatments, drugs available in clinical trials or for compassionate use were not captured in the drug databases because they were outside the study scope of health care costs publicly funded by the Ministry of Health. Fourth, out-of-pocket expenses, private payer costs, and indirect costs (e.g., lost productivity) were not calculated because this costing analysis was from a public payer perspective (e.g., direct medical costs paid for by the health care system). Thus, this is not a fulsome analysis of the economic impact of breast cancer, and costs are potentially underestimated. Fifth, some elements of breast cancer care, such as screening procedures, have not been included in this analysis and would likely impact costs, as well as lead to a different study being conducted on breast cancer screening costs.<sup>13</sup> Sixth, costs could not be calculated separately by specific service, such as radiation therapy, so radiation oncologist visits are embedded in the overall OHIP specialist costs, while technical personnel (e.g., physicists, radiation therapists) are included in non-physician costs. Seventh, the impact of the COVID-19 pandemic on costs for women diagnosed with breast cancer from 2017 to 2021 was not evaluated because the data during the timeline of the pandemic were already included in the existing costing results, and the analyst would need to use a different censoring date. It was not a study objective to investigate the impact of the pandemic on the overall cost results. Also, it is important to highlight that breast cancer incremental costs for all the fiscal years (2017 to 2021) would contribute more toward the overall incremental cost than only the one COVID-19 year. It is worth noting that an ad hoc cost analysis, in which incremental costs for the 2017 to 2020 calendar years were determined, indicated that incremental costs increased with each subsequent year. The authors recognize that an entirely new study with objectives related to only the pandemic and its impact on breast cancer treatment and care can be conducted in the future. Eighth, study information was from 2017 to 2021 and reflected the standard of care (e.g., systemic treatments, differential utilization of

health system resources) at the time, but it excludes the costs of novel agents (e.g., CDK4/6 inhibitors, immunotherapy, and antibody-drug conjugates). This observation was supported by previous Canadian studies.<sup>14,15</sup>

## Conclusion

This study aimed to address gaps in breast cancer costing studies by providing an updated picture of the financial impact of breast cancer care in Ontario. The findings highlight higher costs for metastatic breast cancer cases, women younger than 70 years, and the initial 12 months following diagnosis. Understanding these cost patterns is pivotal in developing targeted strategies to efficiently manage breast cancer within health care systems. By identifying the specific areas and periods of heightened resource utilization and associated costs, this research provides valuable insights that are crucial for devising more effective and focused interventions, ultimately aiding planning and resource allocation for better support and care of women diagnosed with breast cancer.

## Acknowledgments

This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health (MOH) and the Ministry of Long-Term Care (MLTC). This study also received funding from CIHR (Canadian Institutes of Health Research). This document used data adapted from the Statistics Canada Postal CodeOM Conversion File, which is based on data licensed from Canada Post Corporation, and/or data adapted from the Ontario Ministry of Health Postal Code Conversion File, which contains data copied under license from ©Canada Post Corporation and Statistics Canada. Parts of this material are based on data and/or information compiled and provided by MOH, CIHI (Canadian Institute for Health Information), etc. The analyses, conclusions, opinions and statements expressed herein are solely those of the authors and do not reflect those of the funding or data sources; no endorsement is intended or should be inferred.

Parts of this material are based on data and information provided by Ontario Health (OH). The opinions, results, view, and conclusions reported in this paper are those of the authors and do not necessarily reflect those of OH. No endorsement by OH is intended or should be inferred.

**Appendix 1**  
**Data sources**

<b>DATABASES</b>	<b>DATA VARIABLE</b>
<b>Demographics</b>	
Local health integration networks (LHINs)	14 LHINs, operating as Home and Community Care Support Services organizations across Ontario, providing home care and long-term care home placement services and facilitating access to community services
Registered Persons Database	Basic population and demographic information (age, sex, location of residence, date of birth, and date of death for deceased individuals)
Postal Code Conversion File	Allows for the matching of six-digit postal codes to standard census geographies
<b>Health services</b>	
Canadian Institute for Health Information (CIHI) Continuing Care Reporting System	Complex and continuing care
CIHI Discharge Abstract Database	Inpatient hospitalizations
CIHI National Ambulatory Care Reporting System	Emergency department visits Outpatient clinic visits Same-day surgery
CIHI National Rehabilitation Reporting System	Inpatient rehabilitation
New Drug Funding Program	Chemotherapies (IV)
Ontario Cancer Registry	Cancer diagnoses
Ontario Drug Benefit Formulary	Drug prescriptions
Ontario Health Insurance Plan billings	Physician visits Non-physician (allied health) visits Laboratory services
Ontario Home Care Database	Home care visits

**Source:** ICES Data Repository

# References

1. Statistics Canada and the Public Health Agency of Canada. *Canadian Cancer Statistics Advisory Committee in collaboration with the Canadian Cancer Society*. (Canadian Cancer Statistics) Toronto, ON: Canadian Cancer Society; 2023.
2. Wilkinson AN, Seely JM, Rushton M, Williams P, Cordeiro E, Allard-Coutu A, Look Hong NJ, Moideen N, Robinson J, Renaud J, Mainpriz, JG, & Yaffe, MJ. Capturing the true cost of breast cancer treatment: Molecular subtype and stage-specific per-case activity-based costing. *Current Oncology* 2023; 30(9), 7860–7873.
3. Mittmann N, Porter, JM, Rangrej J, Seung SJ, Liu N, Saskin R, Cheung MC, Leighl NB, Hoch JS, Trudeau M, Evans WK, Dainty KN, DeAngelis C, & Earle CC. Health system costs for stage-specific breast cancer: A population-based approach. *Current Oncology* 2014; 21(6), 281–293.
4. Harfouche A, Silva S, Faria J, Araujo R, Gouveia A, Lacerda M, et al. Breast cancer: Value-based healthcare, costs and financing. [Portuguese]. *Acta Medica Portuguesa* 2017; 30(11), 762–8.
5. Kreis K, Plöthner M, Schmidt T, Seufert R, Schreeb K, Jahndel V, Maas S, Kuhlmann A, Zeidler J, & Schramm A. Healthcare costs associated with breast cancer in Germany: A claims data analysis. *The European Journal of Health Economics* 2020; 21(3), 451–464.
6. Khan SA, Hernandez-Villafuerte K, Hernandez D, & Schlender M. Estimation of the stage-wise costs of breast cancer in Germany using a modeling approach. *Front Public Health* 2013; 10:946544.
7. Wodchis W, Bushmeneva K, Nikitovic M, et al. Guidelines on Person-Level Costing Using Administrative Databases in Ontario. *Health System Performance Research Network*, 2013. [https://hspn.ca/wpcontent/uploads/2019/09/Guidelines\\_on\\_PersonLevel\\_Costing\\_May\\_2013.pdf](https://hspn.ca/wpcontent/uploads/2019/09/Guidelines_on_PersonLevel_Costing_May_2013.pdf)
8. Iwagami M, Shinozaki T. Introduction to Matching in Case-Control and Cohort Studies. *Annals of Clinical Epidemiology* 2022; 4(2), 33-40.
9. Health Services Research & Development Center at The Johns Hopkins University, Bloomberg School of Public Health. The Johns Hopkins ACG System. <https://www.johnshopkinsolutions.com/wp-content/uploads/2014/04/ACG-White-Paper-General-Dec-2012.pdf>. Accessed January 2<sup>nd</sup>, 2024.
10. Hurry M, Hassan S, Seung SJ et al. Real-World Treatment Patterns, Survival, and Costs for Ovarian Cancer in Canada: A Retrospective Cohort Study Using Provincial Administrative Data. *J Health Econ Outcomes Res* 2021; 8(2):114–121.
11. Canadian Partnership Against Cancer Corporation. OncoSim. *Canadian Partnership Against Cancer*. Available at: <https://www.partnershipagainstcancer.ca/tools/oncosim/> Accessed May 17, 2024.
12. Sun L, Legood R, dos-Santos-Silva I, Gaiha S. M, & Sadique Z. Global treatment costs of breast cancer by stage: a systematic review. *PloS One* 2018; 13(11), e0207993.
13. Mittmann N, Seung SJ, Diong C, Gatley JM, Wolfson M, Guertin MH, Pashayan N, Simard J, & Chiarelli AM. Using real-world data to determine health system costs of Ontario women screened for breast cancer. *Current Oncology* 2022; 29(11), 8330–8339.
14. Brezden-Masley C, Fathers KE, Coombes ME, Pourmirza B, Xue C, Jerzak KJ. A population-based comparison of treatment patterns, resource utilization, and costs by cancer stage for Ontario patients with hormone receptor-positive/HER2-negative breast cancer. *Breast Cancer Research and Treatment* 2021;185(2), 507-515.
15. Brezden-Masley C, Fathers KE, Coombes ME, Pourmirza B, Xue C, Jerzak KJ. A population-based comparison of treatment patterns, resource utilization, and costs by cancer stage for Ontario patients with triple-negative breast cancer. *Cancer Medicine* 2020; 9(20), 7548-7557.